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THE MANCHESTER
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MEMOIRS AND PROCEEDINGS

OF

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MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 1st, 1889.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

Mr. WILLIAM THOMSON, F.R.S.ED., F.C.S., exhibited a specimen of aluminium foil, and a discussion on the properties of alloys of the metal, in which Mr. Thomson, Professor Reynolds, Mr. W. H. Johnson, and others took part, ensued.

The PRESIDENT called attention to Mendelejeff's theory of the formation of petroleum from carbides of iron and not as an organic product, which was described in detail in Mr. Anderson's address as president of the Mechanical Science Section of the British Association Meeting at Newcastle, and Professor W. C. WILLIAMSON observed that the theory was in harmony with a fact which had often puzzled him—that petroleum is not found associated with beds containing plant remains.

Mr. CHARLES O'NEIL, F.C.S., communicated an account of a curious phenomenon observed recently at Carrington Moss, where, after the removal of a very large crop of potatoes from about 80 or 90 acres of reclaimed land on which nightsoil had been spread, tomatoes spontaneously sprang up over the area. A discussion ensued on the dissemination of seeds through animal bodies, in which Professor Williamson, Mr. C. Bailey, and Mr. C. N. Adams joined.

The full text of a paper by Dr. ALFRED SPRINGER, of Cincinnati, communicated by Mr. W. GRIMSHAW, on the theories of fermentation, an abstract of which appeared in the last volume of the *Memoirs and Proceedings*, was read, and elicited a discussion on the possibility of forming a committee to revise the nomenclature of micro-organisms and report on the disputed points enumerated in the paper. The general opinion was that the formation of a committee likely to arrive at decisive conclusions was not practicable.

A note by Dr. CHARLES CLAY, "On the rapidity of the Growth of Plants" was read by one of the Secretaries in the author's absence. Dr. Clay said :—" I had often heard of the rapid growth of the *Cobæa scandens*, and when it was stated by Loudon that it had been known to reach 200 feet in one summer, I confess I doubted the statement. This summer (1889) I determined to test it. I procured two plants each, of *Cobæa scandens* ; the Japanese hop; and *Tropæolum Canariense*, species very remarkable for quick growth. These six plants were not more than three inches in length when I put them in the soil on June 12th, each plant being placed in as favourable a position for upward progress as my vineries would allow. At the end of the first month (July 12th) the result was :—*Cobæa*, 8 feet 6 inches ; Japanese hop, 4 feet 8 inches; *Canariense*, 6 feet 2 inches. On August 12th *Cobæa* was 12 feet 8 inches ; the Japanese hop, 6 feet 8 inches ; *Canariense*, 9 feet 8 inches. Thus, so far, *Cobæa* had outgrown both the other plants immensely. Proceeding, as far as my buildings would allow for upward growth, my last measurement showed *Cobæa*, 18 feet 6 inches ; Japanese hop, 10 feet 4 inches ; and *Canariense*, 13 feet. It must be observed that these experiments were conducted in a climate very different to that of the country, Mexico, where it is indigenous, and where its growth must be much more rapid and extensive I propose next year to repeat these trials. I shall only report on the *Cobœa* in future, believing the other two to be so far inferior to the *Cobœa* as not to require further attention. I also propose to begin the next trial from the *seed*."

A discussion ensued, Mr. Charles Bailey and Mr. F. Nicholson alluding to the extraordinary rapidity of growth of the Brazilian *lianas* and the Australian *Eucalyptus*. Professor W. C. WILLIAMSON stated that during the past summer (1889) the plants in his garden and hot-houses at Withington had manifested a quite abnormal vigour and rapidity of growth, and Mr. W. GRIMSHAW described similar phenomena observed at his residence at Sale.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, October 2nd, 1889.

Mr. J. COSMO MELVILL, M.A., F.L.S., President of the Section, in the Chair.

Mr. H. HYDE explained a method of making glass water tanks for micro-organisms and aquatic plants.

Mr. P. CAMERON showed a series of drawings by Miss Constance Abrahall illustrating his work on Gall-insects.

Mr. MARK STIRRUP mentioned an hypothesis that had been set up, that the sporting bifurcations in *Scolopendrium*, etc., are probably caused by fungi, and on this an animated discussion ensued.

Mr. H. C. CHADWICK made a communication on the recent finding of the American clam, *Venus mercenaria*, at Hilbre Island, and Mr. R. D. DARBISHIRE showed for comparison some specimens taken from a colony planted near Grimsby; also a series from New York—the largest of them, an ordinary specimen, measuring 3 inches by 2½ inches, and weighing 12oz.—and a large specimen from a post-pliocene bed on the Caloosahatchia River, South Florida, which measured 5 inches by 4 inches, and weighed 1lb. 7oz.

Mr. J. COSMO MELVILL stated that he wished to put on record a third locality for *Plantago maritima* (L.) form *pumila* of Kjellmann. The localities previously recorded were the original station Cape Grebenig, Insula Wagatsch, Scandinavia, where it was gathered by Lundström and Kjellmann; and Ben Hope, Sutherlandshire, where it was found by Mr. Melvill and Mr. Frederick Hanbury in July 1888. Miss Caroline Birley and Miss Coupland visited the Faroe Islands this year, and gathered the plant at about 1,000 feet altitude on Isle Stromoe. They reported it as being somewhat plentiful there.

Mr. CHARLES BAILEY exhibited specimens of *Arenaria gothica*, Fries, from Ribblehead, Yorkshire, collected by Mr. J. G. Baker, F.R.S., of Kew.

General Meeting, October 15th, 1889.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

Mr. NATHANIEL BRADLEY, F.C.S., Mr. C. F. BUDENBERG, B.Sc., Dr. J. W. TATHAM, and Mr. W. E. HOYLE, M.A., M.R.C.S., were elected ordinary members.

Ordinary Meeting, October 15th, 1889.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

The PRESIDENT said :—

"It is my sad office to-night to make formal mention of the death, which took place at his house, Wardle Road, Sale, of our senior Vice-President, who was also, if I may use the words, our much loved and honoured master, Dr. Joule. Although for the last four years we have missed his presence amongst us, we have still been able to feel the honour of being associated with him as members of this Society, an honour which was peculiarly our own ; for although a member of many societies all the world over, with no other was his connection to be compared with that of the Literary and Philsophical Society of Manchester. His association with these rooms, commencing as it did when he was only 15 years of age, continued, by the most regular attendance, as long as his health would permit, and, terminating only with his death, cannot but have been one of the most important circumstances in his life ; while, on the other hand, the Society will ever cherish the memory of his connection with it as amongst its most important associations. We who have been directly associated with him here, and have felt the encouragement of the keen but kindly interest which he took in all efforts after truth, however trivial they may have appeared to one who had accomplished such great things, will remember this as a continually increasing honour, and as one of the most pleasant memories of our lives. It is not for me now to attempt to place before you any summary of Dr. Joule's work. This will form the subject of a *Memoir* to be presented on a future occasion.

But I feel that it may not be out of place here for me to mention a few of the bare facts, showing his connection with the Society:—A pupil of Dalton's, in these rooms, from 1833, he was elected a member in 1842; he contributed his first paper to this Society's *Memoirs* in 1843. He was elected on the Council in 1846; became Secretary in the same year, and filled that office until 1850. He was our President in 1860–62, 1866–69, 1872–73, and in 1878–79. He was a member of the Society for forty-seven years, and was for forty-three years on the Council, being Secretary five years, President for ten years, and Vice-President for 28 years. I have not yet had time to take out the number of papers he presented to the Society, or to look over the attendance book; but his attendance was most regular, and the interest he took in everything concerning the well-being of the Society was most keen, and for an unusually long series of years he took a very important part in conducting the business of the Society."

The PRESIDENT then stated that a resolution expressing sympathy with the members of Dr. Joule's family had been adopted by the Council, and it was

Moved by Mr. H. H. HOWORTH, M.P., seconded by Mr. Alderman W. H. BAILEY, and resolved: "That the members generally be associated with the Council in this expression of condolence."

It was further announced that the Council had entrusted the preparation of a *Memoir* of Dr. Joule's life and work to the President, Professor Osborne Reynolds.

Mr. W. THOMSON, F.C.S., called attention to a remarkable pattern of asbestos cloth which had been produced on
irface of an iron tube exposed to a bright red heat for
hours. The iron was first covered with china clay,
en wrapped with asbestos cloth to prevent it from oxidation and burning away. It did not entirely protect it, because a scale of oxide of iron about one-sixteenth of an

inch thick was produced showing the pattern in relief both on the surface and behind, giving a perfect pattern of all the threads of asbestos. Specimens were exhibited.

Mr. CHARLES BAILEY, F.L.S., read a paper on "*Arenaria gothica*, E. Fries, as a plant new to Britain," and exhibited specimens, together with specimens of allied species.

Mr. F. J. FARADAY, F.L.S., exhibited and read selections from a collection of 640 autograph letters forming the correspondence of Colonel John Leigh Philips, cotton spinner and naturalist (b. 1761, d. 1814), and one of the first members of the Society, and stated that the letters, which were alphabetically arranged in five portfolios, had been purchased for presentation to the Society's library by Lieut. Herbert S. Brooks.

It was moved by Mr. Faraday, seconded by Mr. F. Nicholson, and resolved: " That the special thanks of the Society be given to Mr. H. S. Brooks for his interesting and valuable gift."

Arenaria gothica (*E. Fries*) as a plant new to Britain.

By Charles Bailey, F.L.S.

(*Received October 15th, 1889.*)

The specimens of *Arenaria gothica*, Fries, now submitted to the members, as representing a recent addition to the flora of Great Britain, were collected at Ribblehead, Yorkshire, in September last, by one of our honorary members, Mr. J. G. Baker, F.R.S., F.L.S., of Kew, the locality having been first discovered by Mr. Lister Rotheray, a Skipton botanist. Its occurrence in Britain is noteworthy from the side of phytogeography, and it is very difficult to explain why it has not been met with previously, as the district round Ingleborough is classic botanical ground.

So far as has been recorded the typical *Arenaria gothica* is restricted to two Swedish localities, viz., to Kinnekulle mountain, in the province of Skarabog to the south of Lake Wener, and to the island of Gothland, chiefly in the neighbourhood of Wisby. Sheets of specimens from my herbarium are shown for comparison ; from Kinnekulle, collected by Lindgren, J. Bergmann (July, 1850), F. Ahlberg (27th June, 1862, and July, 1870), A. André (July, 1871), C. O. Schlyter (25th June, 1875), and C. J. Johanson (18th July, 1878); and from Wisby, collected by P. F. Lundquist (July, 1883), and O. Olsson (9th July, 1883). The same species, or some geographical form of it, occurs at the edge of the Lac de Joux, 3,310 feet above the sea, and at the feet of two of the highest mountains of the Jurassic Chain,—Mont Tendre, and Dent-de-Vaulion ; in C.-M. Philibert Babey's "Flore Jurassienne" (1846), Vol. I., p. 255, this Lac de Joux plant is considered to be *Arenaria multiflora*, Koch ; in Grenier and Godron's "Flore de France" (1848), Vol. I.,

p. 259, it is identified with *Arenaria fugax*, Gay, and reduced by them to a variety of *Arenaria ciliata*; in Ch.-H. Godet's "Flore du Jura" (1852), Vol. I., p. 104, it is given as *Arenaria ciliata*, L.; and Ch. Grenier, in his "Flore de la Chaîne Jurassique" (1865), Vol. I., p. 122, makes the following remarks:—"La plante des bords du lac de Joux me semble très voisine de l'*A. gothica*, Fries, si ce n'est pas elle. Mais il est difficile, dans des espèces aussi voisines, de trancher semblable question sur quelques exemplaires desséchés."

At the meeting of the British Association, held last month at Newcastle, where Mr. Baker exhibited these particular specimens of *Arenaria gothica*, he pointed out the close relationships of *A. ciliata*, L., *A. norvegica*, Gunn., *A. multicaulis*, L., and *A. gothica*, Fries, and he regarded all these as belonging to one superspecies which had undergone modification, and which were connected with each other by intermediate forms. The Lac de Joux plant referred to above is probably one of such intermediates, but I do not possess specimens.

Nyman, in his "Conspectus Floræ Europææ" (1878) part I., pp. 114-115, arranges *A. gothica* in an annual or biennial group, while the other species named above come under a perennial group. The Ribblehead specimens now before the members are annual, not perennial; and most of their other characters range under *gothica* rather than *norvegica*.

In the British Islands we have some representatives of the perennial group, as *Arenaria ciliata*, L., has long been known to occur in county Sligo, on Ben Bulben and King's Mountain, specimens from which localities are now exhibited; and *Arenaria norvegica*, Gunner, in the Shetland Islands, whence came the plants now shown, viz., from serpentine rocks in Balta Sound on the eastern side of the island of Unst, collected by the Rev. Dr. A. M. Norman (June, 1883), and W. H. Beeby (26th July, 1886, 30th August, 1887). With them is a large suite of European forms of *Arenaria ciliata*, and Norwegian specimens of *A. norvegica* from Saltenfjord, Nordland, collected by W. Arnell (July, 1869). Mr. J. Cosmo Melvill has Icelandic specimens of *A. norvegica*, collected near Tuihiara (4th July, 1846).

As will be seen from the sheets of *Arenaria ciliata* they are all characterised by a difference of habit from what we see in the Ribblehead *Arenaria*; the latter, though having a stem with several branches arising from the base, has its branches erect, whereas *ciliata* has a much larger number of diffuse prostrate leafy branches springing from the rootstock. In some of the plants of *ciliata* now exhibited the leaves are in close ranks upon the stems, whereas others are seen to be in scattered pairs more like those of *A. serpyllifolia*, L. If the localities are examined it will be seen that the stunted close-leaved forms are high alpine forms, while the broader-leaved forms, with the pairs of leaves more distant, come from the richer ground of the lower slopes of mountains. The localities of these plants will show the wide European range of the species:—Finmark: Kaafjord, Th. Fries (12th July, 1864). Switzerland: Klimsenhorn, one of the seven peaks of Pilatus, Dr. Winter Dursheim (11th August, 1880), and A. Hurlimann (August, 1882); Alpes de Bexe, P. Chenevard (11th August, 1879); the Niesen, in the Bernese Oberland, Mouillefarne (27th September, 1883), Riffelberg, 2570 mètres (var. *frigida*), P. Chenevard (26th July, 1880), and Rosalie Masson (5th August, 1881). France: the Niesen, in Savoy, Eug. Didier (3rd September, 1854); Mont Nanan, in the Alpes-Maritimes, and Briançon and Mont Aurouse in the Hautes-Alpes, Elisée Reverchon (6th July, 1886, 10th July, 1867, and 19th July, 1871). Tirol: from Weissenbach, &c., G. Treffer (25th August, 1879, 21st July, 1881). Carinthia: Glocknerhause, C. Bænitz (18th July, 1887). Carniola: Ojsterc, L. Kristoff (15th July, 1869).

Upper Austria: Windischgarten, Oberleitner (9th July, 1863). Italy: Verona, Monte Baldo, G. Rigo (15th July, 1878). It also occurs in the Spanish Pyrenees in all the subalpine region, but I have no specimens from thence.

Of *Arenaria multicaulis*, Wulfn. in Jacq., I can exhibit specimens only from Central Tirol, Monte Fusterstern, R. Huter (August, 1881); and from Carinthia, Wischbach, R. Huter (30th July, 1875); but it occurs in the Kronstadt Alps in Transsylvania. It can scarcely be considered anything more than a local form of *A. ciliata*, and it is difficult to separate the two.

It may be useful to give the characters which differentiate these species, and I cannot do better than extract them from the "Novitiarum Floræ Suecicæ, Mantissa altera," of Elias Fries (Upsal, 1839) pp. 33 to 35:—

"*Arenaria gothica*, caulibus e basi ramosa erectis teretibus simplicibus, alis nudis, foliis ovalibus lanceolatisque abrupte acuminatis glabris, basi attenuata subciliatis, sepalis carinatis petalis capsulaque ovata brevioribus."

"Radix omnino annua; seminibus dispersis tota planta fugax. Caules basi divisi in ramos ex adscendenti mox erectos, 1—2 unc. longos, semper [etiam exsiccati] teretes, apicem versus puberuli. Folia distantia, parva, tenuia, sicca nervo dorsali carinata; semper in apicem abrupte acuminata. Pedunculi terminales vulgo terni, stricti. Sepala patentia, ovato-lanceolata, itidem acuminata, nervosa, et nervo dorsali manifeste carinata. Petala ovalia obtusa; stamina inclusa. Capsula ovata apice constricta, dentibus revolutis dehiscens. Semina reniformi-globosa, parum depressa, sub lente granuloso-scabra, atra." [Figured in Flora Danica, t. 15].

"*Arenaria ciliata*, caulibus cæspitosis ramosissimis diffusis, in alis folioloso-ramulosis, foliis minutis carnosulis ovatis lanceolatisve acutiusculis obtusisve, basi attenuatis, pedunculis terminalibus, sepalis ecarinatis (siccitate trinervibus)acutis petalis capsulaque oblongis brevioribus."

"Var. *vera*, cæspitibus laxioribus, caulibus elongatis foliis latioribus acutiusculis subciliatis siccitate nervosis. *Ar. ciliata*, Fl. Dan., t. 346."

"Var. *norvegica*, cæspitibus densioribus, caulibus subabbreviatis, foliis lingulatis obtusis imbricatis glabris, siccitate corrugatis. [Figured in Flora Danica, t. 1269.] *Ar. norvegica*, Gunn. *Ar. humifusa*, Wahl. (specimina maxime contracta et frigida, quoad specc. e loco, sed flores l. ind. vulgo pedunculati nec nisi unum alterumve flore sessili videre licuit). *A multicaulis*, Linn. et Gunn. huic accedit."

Similar diagnoses are given in the "Summa Vegetabilium Scandinaviæ," sectio prior, p. 158.

Upon comparing the Ribblehead specimens with the above definitions of the several species, it will be seen that, though they are more robust than Swedish examples, the leaves are not in corrugations or wrinkles when dry, but clearly show the median nerve, that they are acuminate rather than obtuse; that the stems are more erect than prostrate; that the sepals are manifestly keeled; and that the teeth of the capsule after dehiscing are revolute, not erect—a point emphasised by E. Fries in the diagnoses of his "Summa." They therefore rank with *Arenaria gothica* rather than the other forms.

I have not personally seen the station in which the plant occurs in Yorkshire, but it is said to be most copious. Mr. Baker found it in one spot only, on the road side, growing amongst the broken stones used for repairing the roads; he searched for the plant on some of the neighbouring scars during the short time he had, but unsuccessfully.

Selections from the Correspondence of Lieutenant-Colonel John Leigh Philips, of Mayfield, Manchester. Part I. By F. J. Faraday, F.L.S.

(*Received January 6th, 1890.*)

John Leigh Philips was born in Manchester on November 23, 1761, and died at the age of fifty-three on June 23, 1814. He was the eldest son of John Philips, who represented an off-shoot from an old Staffordshire family—the Philips's of Heath House, near Cheadle, in that county, where they were settled as far back as the reign of Edward VI., being lords of the manor of Upper Teyne, Nether Teyne, and Checkley.

Nathaniel Philips, born in 1698, a younger son of Nathaniel Philips, of Heath House, removed to Manchester and engaged in trade early in the eighteenth century, apparently as a silk manufacturer, and he married Elizabeth Burton, of Derby, in 1729. His sons were Nathaniel Philips, born in 1730, and the before-mentioned John Philips, who was born in 1734, and they appear to have carried on their father's business in partnership in Queen Street, St. Ann's Square. John Philips married Sarah, daughter of George Leigh, of Oughtrington Hall, Cheshire. In 1777, when his son, the subject of this notice, was sixteen years of age, he purchased Bank Hall, in the township of Heaton Norris, and resided there until his death, at the advanced age of 90, in 1824. Thomas Philips, of Sedgeley (father of Sir George Philips of Sedgeley and Weston, who became a member of the Manchester Literary and Philosophical Society in 1783, and remained a member until his death in 1847), was a cousin of this John Philips, being a younger son of the elder branch of the family which remained in Staffordshire. He was born in 1728. He, also, came to Manchester, with his brother Nathaniel, born in 1726 (the grandfather of Mark Philips, M.P.), who must not be confounded with either of the two Nathaniels who were respectively the father and the brother of the John Philips of St. Ann's Square. The brothers Thomas and Nathaniel also entered into partnership, and thus two collateral branches of the Staffordshire family were carrying on business in Manchester at the same time.

John Leigh Philips was a pupil of Henry Clarke, the well-known mathematician, at the "Classical and Mathematical School in Salford, Manchester," and he solved three problems in the *Town and Country Magazine* in 1775. He held a commission as second Lieutenant in the corps of Volunteers raised in 1777 (which afterwards became the famous 72nd), he being then only sixteen years of age. His name occurs in the list of those who constituted the Manchester Literary and Philosophical Society on its formal establishment in 1781, and though then apparently only about twenty-one years of age, he was a member of the Society's first Council or "Committee of Papers." He was, I believe, subsequently a partner in the firm of Philips and Lee, cotton spinners, who carried on their business at 53, Chapel Street, Salford, and he also, with his brother Francis, carried on his father's and uncle's business in Queen Street, St. Ann's Square, and in Cross Street, as a silk and cotton manufacturer, the firm being known as J. L. Philips and Brother. The mill in Chapel Street was the first to be lit with gas—in 1805. In 1787 he married Caroline Penny, and afterwards resided at Mayfield, then a rural suburb of Manchester. He was an enthusiastic patron of bibliography and the arts, and especially a promoter of engraving. He was also a collector of natural history specimens. In 1815, after his death, his books, paintings, prints, and natural history collection were dispersed by auction in Manchester, and realised the sum of £5,474. 15s. 3d., the natural history specimens eventually forming the nucleus of the Manchester

Natural History Museum, formerly situated in Peter Street, and now located in the new building in Oxford Street, forming part of the Owens College. He was for many years treasurer of the Manchester Infirmary, and became Lieutenant-Colonel of the First Battalion of Manchester and Salford Volunteers. In 1804 he went out to fight a duel on Kersal Moor with Lieutenant-Colonel Joseph Hanson, but was arrested and bound over to keep the peace. He was himself a Justice of the Peace. He appears to have been associated with the foundation of the Portico Library in Mosley Street. The letters give evidence that he was a very liberal friend, and a keen sportsman with both the gun and the rod. They include many grateful acknowledgments. Barrels of oysters seem to have been favourite gifts, and also hares, wood-cocks, and other game. He was likewise apparently a lampoonist, and a critic of men and books. He was an occasional contributor to the *Monthly Magazine*, and in 1797 published a memoir of his friend Joseph Wright, of Derby, the painter, in that magazine, with a catalogue of Wright's works.

The collection of autograph letters and other manuscripts (in all about 640) is contained in five portfolios, and, having lately come into the market, was purchased by Lieutenant Herbert S. Brooks, and has been presented by him to the Society's library. This valuable memorial of one of the Society's first members is a graceful gift from one of its latest recruits. The letters are very neatly arranged alphabetically. Colonel Philips left two sons. The eldest of these was Mr. Nathaniel G. Philips, an amateur landscape painter and etcher, old halls and other scenes in Lancashire and Cheshire having been favourite subjects with him. This son died at Childwall, near Liverpool, on August 1, 1831. A few of the letters in the collection are addressed to him, and others are addressed to Mr. Daniel Daulby, of Liverpool, a frequent correspondent of Colonel Philips's, to whom the letters in question were probably enclosed by Mr. Daulby in connection with the subject matter of their own correspondence. The last surviving son of Colonel Philips was Lieutenant John Philips, R.N., who also died in Liverpool, on June 2, 1835.

For the present instalment of the correspondence I have selected letters which throw light on the character and avocations of Colonel Philips, his circumstances and surroundings, and the local events of the period. I print them with all mis-spellings and other peculiarities retained. The first place may appropriately be given to a letter by his former schoolmaster, Henry Clarke, which may possibly be the only manuscript from the pen of that distinguished mathematician now in existence. It is as follows :—

Sir,

Have sent the Dozen Copies of the Tab. Linguar. you were so obliging to order. Should have sent them sooner, but could not get them out of the Binder's hands. I intend removing to Manchester in a few weeks, but sho^{d} esteem it a favour, Sir, if you could inform me in the meantime, whether you have thought anything more of the Appointment in the Counting-house you were so obliging to mention to me—as I sho^{d} indeed perfer that Situation by much to the commencing School again. I have a good School here as usual, but my Wife's ill state of health, (who is here with me) and her desire to live in Manchester, render it requisite to return there & if possible, to withdraw into a Line of Life that will be more private, and that may be attended with less fatigue to *her*. I have had several very eligible Situations proposed to me since I have been here, but I sho^{d} rather chuse Manchester, and could be proud to be engaged in Mr. Leigh Philips's Connection, were I to go into a Counting-house. I have no doubt but I could in a few weeks be able to go through the business with accuracy & dispatch; and, at the same time, Sir, you might depend on Integrity, Assidüity, and *Steadiness*,—for, it is now long since that I have sown all my "Wild Oats"—the few irregular shoots that have appeared latterly being only from some scattered Grains that unfortunately remained at the bottom of the bag.

I am
Sir
Your very obliged h$^{bl.}$ serv$^{t.}$
H. CLARKE.

Liverpool
Mount Pleasant
Feby. 10th 1794.

If Mr. Philips wo^{d} have dropt H. C. a line in a few days it wo^{d} have been esteemed a favour.

John Leigh Phillips, Esq.
Manchester.

This letter had evidently not come under the notice of that careful biographer of Dr. Clarke, Mr. John Eglinton Bailey, and it helps to fill a gap in the record. Mr. Bailey points out that, after Clarke's residence in Liverpool for a year or two, he was apparently again established in 1794 in Manchester as a schoolmaster at 12, Spring Gardens. The above letter indicates that he left Liverpool early in that year. The reference at the beginning of the epistle is to his *Tabulæ Linguarum*, which was published in 1793. The letter shows that at this time (at the age of 51) he was apparently on the point of abandoning the scholastic profession for ever. It seems probable that he found occupation in connection with the Manchester New College. The memoir in the *Gentleman's Magazine*, quoted by Mr. Bailey, states that during this period he made a collection of philosophical instruments, and he appears to have removed to Bristol about 1797. In 1802 he was Professor of History, Geography, and Experimental Philosophy at the Royal Military College, Great Marlow, which was subsequently removed to Sandhurst; and in the same year he received the degree of LL.D. from the University of Edinburgh. The caligraphy of the letter is remarkable for its copper-plate-like character and elaborate flourishes, in keeping with Mr. Bailey's description of Clarke's signature in the marriage register of the Old Church (Manchester), as "the unmistakeable hand of a Dominie."

The writer of the following letter was the Hon. Sir John Talbot Dillon, Knight and Baron of the Holy Roman Empire, who was elected an honorary member of the Society in 1784. Dillon was a traveller, critic, and historical writer. He spent much of his time in travelling in Italy and Spain, and residing in Vienna. He was created a Baron of the Holy Roman Empire by the Emperor Joseph II. "in recognition of services in behalf of his Roman Catholic fellow-subjects," and was made a baron of the United Kingdom in 1801. His "Travels in Spain" went through several editions and was translated into German. Amongst other works from his pen were:—"Political Survey of the Sacred Roman Empire," "Letters from a Traveller in Spain on the Origin and Progress of Poetry in that kingdom," "Alphonso and Eleonora, or the Triumphs of Valour and Virtue," and a "Treatise on Foreign Agriculture," translated from the French of the Chevalier de Monroy. He also translated from the Spanish a work entitled "Sketches on the Art of Painting." One of his most interesting works, entitled "Memoirs of the French Revolution," is valued as containing original documents and expressing the views of a contemporary. He was a strong advocate of religious liberty:—

> Baron Dillon presents his Compliments to Capt. Leigh Philips and is much obliged to him for the favour of his kind note from Parliament Street which tho' dated on friday morning only came to his hands on Saturday night at a late hour.—as it mentioned that Capt. P. was to Set out on Sunday morning for Manchester it prevented him from the pleasure of waiting on him which he certainly should have done had he known before of his being in town & with many thanks for his kind offers of service at Manchester begs leave to reciprocate the same to him here upon all occasions—Capt. Philips will please to be assured that John Talbot Dillon will always preserve the most steady regard & attachment for the Manchester Military association & should ever the occasion offer to assert those principles of Loyalty, freedom & defence which Distinguishes that Corps, J. T. D. will ever be ready to rejoin them in defence of the same, and with every good wish for their prosperity hopes they will still consider him as a Brother,—not without the pleasing prospect of paying them a visit in the course of the Summer.
>
> Howland Street 31 May 1784

The following letter probably refers to a request made by Dr. Charles White, F.R.S., one of the four original vice-presidents of the Society, in connection with the formation of his anatomical museum, which was eventually presented to the Manchester Lying-in Hospital. The request may have been made through Mr. Philips because of his influential relations with the London art world. The writer was Paul Sandby

(1725—1809), who is said to have been the first English artist to infuse nature into topographical drawing and the first to etch and engrave in the style known as aquatint. The secret of this method was purchased by the Hon. Charles Greville from a French artist and communicated by him to Sandby. Many of Sandby's drawings were purchased by Sir Joseph Banks :—

Dear Sir

I laid Dr. White's request before the president at the first meeting of the Council of the Royal Academy which was soon after I received your Letter, it was then agreed he should have a Cast from the large Anatomical figure, but I was desired not acquaint you of it till the minutes were confirmed by a second meeting, which did not take place ill last night. I have now the pleasure of acquainting you that I have obtained leave to get one cast soon as convenient, I desired Mr. Corline to get one out of the mould soon as possible, but he said the cold weather was much against it, but promises to let me have one soon as it can be done with safety and that I shall only pay the expense of the Plaster please to signify the same to Dr. White and that the President and Council readily granted it as they wish to cultivate the Arts thro' the Kingdom, at the same time I can assure you no Academician has yet obtain'd a Cast of that perfect figure,—I have been under anxious uneasiness for the long delay, as it might appear I was neglectful, the cause was the illness of Sir W^{m} Chambers our Treasurer whom we was happy to congratulate last night on the recovery of his health, and like Old Dons we ended, and began the New Year which my head yet tells me was only fit for young folks and New Stile, please to present my Respects to Dr White and Mr. Kershaw &c.

I am Dear Sir
with great respect your
much obliged humble serv^{t}
P. SANDBY.

London Jan^{y} 12
1787

The allusion to "Moreland" in the following letter is probably to Mr. Patrick John Mc.Morland, miniature painter, who was born in Manchester in 1741, and died in Liverpool in 1841, being then in his one hundredth year. He was an intimate friend of Mr. Philips's. The letter, like many others in the collection, testifies to the open-handedness which seems to have been a conspicuous trait in Mr. Philips's character:—

Baguley, Jan$_y$. 25, 88.

Dear S$^{r.}$

I am very much obliged to you for your kind and very acceptable Present; to my Daughters it is particularly acceptable, as it will enable them at some Entertainment to astonish, and outshine their neighbours; But I must beg of you to put some Limits to the Frequency and Variety of your Presentments, or you will soon exhaust my Invention in varying the Modes of expressing my Obligations to You for them. I had the Pleasure of hearing from Mr. Wakefield that he w^{d} certainly pay me a Visit at Baguley some Time this Winter; But if you have an Oppurtunity it will not be amiss to inform Moreland, that Mrs. Egerton has expected him this Xmas at Withenshaw; that Mr. Egerton, Herself & young Mr. Tatton set out Yesterday for York, where they purpose to stay ten or twelve Day, and that the Young Gentleman will not remain at Withenshaw, after their Return, more than Week, w^{ch} will be the only time that Moreland will have to finish his Picture. I fancy Mrs. Egerton will let him know the Day of their Return, when that is precisely fixed, but it may be of some Use to let him know beforehand ab^{t} what Time that will be, that he may not make any other Engagem^{t} wh^{ch} may interfere with it.

All here join in wishing you many, many happy new Years with your most obliged humble Serv$^{t.}$ JOHN HOUGHTON.

Your's & M^{c} Knivin's company will add much to my Pleasure, when our common Friends favour me with theirs at Baguley.

The following letter from Dr. (subsequently Sir) James Edward Smith, the first President of the Linnean Society, testifies to Mr. Philips's interest in botany and horticulture. From subsequent allusions in the correspondence, I am inclined to think that the inquiry had some relation to the commercial use of the colour. It may, however, have been preferred in the interest of some of Mr. Philips's artist friends. Richard Pulteney, M.D., F.R.S., was the author of "Sketches of the Progress of Botany in England, from its Origin to the Introduction of the Linnean System," published in London in two volumes in 1790:—

London June 28. 1791.

Dear Sir

I ought to have answered y$^{r.}$ favor long ago, but I flattered myself with being able to find some way of sending you some of Sowerby's red col$^{r.}$ He does not seem to wish to keep it a secret but will send you some, if you will accept it, & an acc$^{t.}$ of what it is. How shall it be conveyed? He says however the great effect is owing to the manner in which it is used. However, I know he will tell you all in his power.—Dr. Pulteney is much obliged to you for yr. correction of what he has said abt. Harrison's Herbarium. He writes me that his information was recd. long ago from Mr. Stephen Bolton, brother of the present writer on Fungusses.

Our Gardens abound now in new Orchideæ, the gardeners have just learnt how to manage them.

I am Dr Sir
Yr very faithful
frd. & servt.
J. E. SMITH.

Sowerby (the natural history draughtsman and engraver, who illustrated Sir J. E. Smith's works) duly communicated the desired information in the following letter. Mr. Charles Bailey suggests to me that the plant alluded to was *Euphorbia Esula*, for which there was an old synonym *Tithymalus pineus* :—

Dear Sir,

Understanding by mine and everybody's worthy Friend Dr. Smith, that the coloring of the *Euphorbia Pinna.* meets your approbation, and you have a desire to know how it is prepared—I shall allways be glad to give every information my slender ability will admit. Being but simple myself, I use very simple means in most of my endeavours, and very seldom anything more than comn Gum Arabic water to any color ; with which the present specimen of carmine is tempered, the most proper quantity is best learn't by me, and I think it will appear richest when there is just Gum enough to keep it on the vellum, or paper &c. More seems to deaden it (or at least wou'd not represent the *Euph:a Pina.*) and less would be very inconvenient as it would so easily rub of.

I have laid some nearly as bright as it may be tho' probably experience will soon surpass anything I can attempt, no doubt when you see what is done, by more knowledge, carefullness, and nicety will far excell.

The next difficulty to my comprehension is the altering the shades which proceeds from and infinite variety of causes. In this nature is our best guide, it often seems to change the local tints.

I wish I could say more to the purpose but must beg you to except this as it is intended and I remain

JAS. SOWERBY

1791
July 19th
2 Mead Place
Lambeth

The writer of the following was Christian von Mechel, the engraver, who was born at Basle in 1737. He studied in Germany, France, and Italy, and was elected a member of the Academy of Florence in 1765. Later on he became a dealer in works of art in his native town. In 1806 he was elected a member of the Berlin Academy, and he died in Berlin in 1815. Amongst his best known plates are portraits of Joseph II., Frederick II., Lord Heathfield, and Lavater. The "Mr. Radcliffe" referred to was the Rev. John Radcliffe, Librarian of the Chetham College, and the compiler of the two first volumes of the *Bibliotheca Chetamensis Catalogus.* He was elected a member of the Society in 1793:—

Liverpool ce 27 Oct. 1792.

Cher et estimable Mr. Philipps

Recevant dans ce moment l'honneur de Votre lettre d'hier avec une lettre de change dedans de 30 Post je dis trente Livre Sterlings, a votre ordre, je ne veux point manquer de Vous le marquer pour etre exact & en regle. Cette somme sera decompté sur ce que Vous avez et receverez encore de moi de Londres, d'ou aussitot mon retour je ne manquerois Vous envoier ce que vous desirez, ainsi qu'a ce bon & brave Ami Mr. Radcliffe auquel je me recomande pour un de ses Catalogues de votre Bibliotheque publique. Come cela ne presse pas, si q.qu'un de votre connoissance va a Londres envoie moi un exmple. a notre ami Francillon. J'ai bien du contentement ici de la connoissance de Mr. Roscoe le savant de Mr. Daulby son beau frere de Ms. les freres Rogers &c. &c. je ne m'attendais jamais trouver tant d'amour pour les arts ici ou je croiois que seul^t.^ Mercure & non Minerve domineroit. Nous avons été ce-jour-ci chez Mr. Blundell a Ince Hall et chez Mylord Derby a Knowsley. J'ai trouvé là un de beaux tableaux de Rembrandt que j'ai vu de ma vie et un sujet de nuit bien convenable a Rembrandt, Le Repas de Belsazer et la main qui ecrit sur la muraille. En attendant que je vois des Tabl. Vous vivez dans les fêtes. Eh bien soit grands bien Vous fassent. Je me recomande a toute votre chere famille y compris l'aimable Mr. Dulieu. Nous partons apres demain pour Chester Bristol & Bath. Adieu cher & aimable amateur de la nature et des arts recevez les assurances du devouement parfait de votre tres sin. Serv^t.^

CHR. DE MECHEL.

The writer of the following letter was James Heath, subsequently the engraver of Benjamin West's "Death of Nelson." The allusion to Jack Bannister—"whose gaiety, good humour, cordial feeling, and natural spirits, shone through his characters and lighted them up like a transparency," says Hazlitt—indicates that Colonel Philips's sympathies extended to the drama as well as to science and the arts :—

Dear Sir.

Jack Bannister's Sister (whose name is Swindle) and her husband are shortly to have a benefit at Chester. He desires me to ask you if you know any persons there, if you do and will give yourself the trouble of writing a line to them under cover to Mr. Swindle at the Theatre Chester he will esteem it a great obligation. Last Saturday I sent you a drawing of Peter Pindar's I have been waiting for a letter but he is so taken up with his new weekly publication he can do nothing else.

I shall prove the Pierson in about a fortnight when I shall be able to guess when it will be compleated. I shall very soon send you a proof of the dead Soldier with the Figures etch'd.

My health is perfectly restor'd, and I am going on in all my pursuits with great pleasure and expedition.

It is a long time since you was in town when may we expect to see you? I hope you and yours are all well.

I am ever yours

JAS HEATH.

Novr 12, 1794.

The following from the same writer gives us a glimpse of Philips's relations with the literary and musical world, and at the same time makes us acquainted with the fact already mentioned, that he was an open-handed sportsman. It would be interesting to know what it was that Philips wrote which proved so pleasing to the author of "Tom Bowling":—

Dear Sir.

I thank you for a very fine Pine apple which I ought to have done long ago, but the truth is I am so little in the habit of writing that I drive it off as long as I can. You must not impute this to want of friendship or respect because I have no friend in the world I value so much as yourself. I told Dibdin what you had written about him and he was very much pleas'd and desir'd me to remember him to you the next time I wrote. I have promis'd to deliver the Major finish'd before Christmas. I have prov'd it lately & it comes to the satisfaction of every one. I wish you could be in town at the time as I intend giving a jolly dinner to all my friends on the occasion.

The Dead Soldier goes on & I intend to finish the figures immediately after the Major is gone.

We have put the letter press of our Shakspear in Busby's hands and we mean to publish in March for certain.

I have not had a bit of Game the whole Season and unless you stand my friend I shall be badly off. It is the only thing in the world I can beg for and I know you will excuse me for mentioning it.

I am
Yours ever
JAS HEATH.

Novr 17. 1795.

It does not appear to whom the following letter from Dr. Ferriar was addressed. It may possibly relate to some negotiation in which Philips's interest was enlisted. From an endorsement it appears that the proposal was declined. I insert the letter here because it is included in the collection, is in the handwriting of one of the most distinguished of the early members of the Society, and has a bearing on its literary history :—

Gentlemen

Manchester July 1t 1797.

You will be pleased to send me Dr. Wharton's Edition of Pope's works, which I see is just published, & to place it to my account.

I have desired Mr. John Burn to procure me a few plates to complete my set of Grose's Antiquities : if he sends them to you, I shall trouble you to pay him for them. But do not delay sending Dr. W.'s Pope.

What should you think of publishing an edition of Tristram Shandy with notes? Since I wrote my Comments on Sterne for the Philosophical Society here, much curious matter has occurr'd to me for illustrating that book.

I am, Gentlemen,
Your respectful hble Servt.
J. FERRIAR.

The writer of the following epistle—George Bew, M.D.—like Dr. White, was one of the first four Vice-Presidents of the Society and was also, like Mr. Philips, a member of its "Committee of Papers." He was himself the author of a paper on "Blindness," read before the Society in 1782, and published in the first volume of the *Memoirs*. The letter throws additional light on Philips's character and habits :—

Dear Sir

I beg to return my respectful acknowledgements for the kind recollection with which you honour me, and for the favour of engaging an early impression of Mr. Heath's Plate. From the unpleasant public altercation which I observed between him & Mr. Boydell, together with his impaired stat of health, of which I had heard, I apprehended he might have relinquished the prosecution of so large a work. It affords me real satisfaction to find he has completed the undertaking, the excellency & superiority of which, I have no doubt, will highly gratify the Amateurs of chalchography. I was particularly pleased with the earlier productions of his graver ; and even the small pieces, on which he probably only bestows some finishing touches, have always something of firmness & delicacy which few Artists are able to effect.

A few weeks since a gentleman with whom I dined in the country, shewed me a letter from our friend Mr. Daulby of Liverpoole. I find he has determined to fix his residence in this neighbourhood ; and a situation is engaged for him between the two Lakes of Windermere and Coniston. We have some who relish the fine arts among us. Mr. Sunderland, who tells me he is acquainted with you, gives with his pencil the most faithful representations of the romantic scenery of this country. Few Gent^n. draw so well. Sir John Lizard, who is now build^g. a house on the borders of the lake, has a number of (performances ?), which he collected during his residence in Italy and Switzerland. Among others, there are some views of the lake of Geneva—the glaciers—&c. &c. painted in opaque water-colour, which are superior to anything of the kind I ever saw.

You are, I presume, perfectly acquainted with the most celebrated beauties of this northern scenery : but there several places, which I have had occasion to visit in the course of my professional duties, that are highly deserving the notice of such as admire romantic display of nature, and which are seldom explored. If you should be induced to revisit this country, let me request you to make your head quarters with me, and I will endeavour to conduct you to objects that may not have already come under your observation. I am very sensible the numerous avocations, which demand your attention, allow you little leizure ; but I know no one who is a greater æconomist of time, or who arranges & employs it to more certain advantage.

Believe me, dear Sir, with sincere respect & regard,

Your faithful humble Serv^t

GEORGE BEW.

Kendal 8^th May 1796

Your orders whenever you please.

The writer of the next two letters was Samuel William Ryley, the author of "The Itinerant, or Memoirs of an Actor." They are interesting in connection with the annals of the local stage. The first of the two letters is endorsed in the handwriting of Mr. Philips "Enclosed £10, May 10." Ryley was born in 1755, and died at Parkgate, Cheshire, on September 12, 1837 :—

Whitchurch May 8th (1800)

Dear Sir

The singularity of my situation will apologise when you understand that circumstanced as I am there is no one within the circle of my friends, your self excepted, that I can apply to who have the power, and will to serve, and who I believe place some confidence in me. Six months ago I purchased the Buxton Theatre for 350£ to be paid at 4 seperate Times, the first Hundred is long since paid, the second is now due, ninety of which I have, but owing to the bad success in this Town I am a little embarrasd to raise the other ten, woud you have the goodness to draw me a bill for Ten Pounds at 2 months and I will remit a Bank note to the amount before it becomes due—My Wife's Uncle Capn Henworthy has left us 200£ but 'tis not to be paid till twelve months after his decease and while the grass grows &c. &c. I open the Buxton Theatre the second week in June when I shoud be happy to see you—If this little accommodation meets your approbation the favor of an immediate line will oblige, at any rate I hope you will not be offended and that nevertheless I may subscribe myself as usual Your Obliged Friend

and humble Servt.

S. W. RYLEY.

Five guineas I already am indebted to your goodness, I woud have paid it more than once, had I been fortunate enough to meet with you at home.

Buxton May 25th (1800)

Dear Sir

Yours including a Draft value 10£ I received, which ought to have been immediately acknowledged, the hurry of removing must plead my excuse—from my *soul* I thank you, and hope soon to return it with more gratitude than I shall attempt to express. I open this Theatre on the 17th of June, at present we are busy enlarging the Stage, make the Pit into Boxes, and what appears rather a paradox, throwing the Pit into the Galry the Box price 4/- Pit 2/6 altogether I hope 'twill more than repay our expense. I am sorry we shall not see you here, the green drake will be on about the 4th of June and surely 'tis a most romantic country, the Artist, the naturalist, and the zebedean I should think, might here spend a week without Ennui. Mr. Banks' share of the Manchester &c. Theatres, is to be disposed of. you will wonder at my presumption, I have become a candidate, and the second on the list—he asks £1500—and will accomodate with time provided he has security—The Manchester Theatre woud doubtless be a fortune to any person of liberality who had spent enough to engage such performers as the Town desires, I think I am the person, and if Banks is at liberty to give me the refusal, I shall endeavour to find friends to support me, tho', at present, they are to seek. I believe I am not at liberty to make the above terms publick altho my anxiety to accomplish so desirable events leads me to trouble you with my concerns. Since I have seen you my family is increased, a little ring taild Monkey, and a Parrot, form our domestic circle—they create a foolish but innocent amusement—I hope Mrs. Phillips and her sweet children afford you a more rational one. To them please to give our sincere good wishes and believe me Dear Sir

Your obliged Friend and
Obedient Servnt
S. W. RYLEY

The following relates to the history of the corps of Volunteers in which Colonel Philips held a commission, and the affairs of which seem to have been prominent in the events of his active life :—

Sir

In Answer to your Letter of the 27th Instant received last Night, I have the Honour to inform you that I have this day recomended to his Majesty thro' the Duke of Portland, the Gentlemen named on your List for Promotion & Appointment in the 1t. Battalion Manchester & Salford Volunteer Infantry occasioned principally by the resignation of Lt. Col. Bayley to whom I have written upon the subject by this Post.

I have the Honour to be
Sir
Your Obt. humble Servt.
DERBY.

Knowsley
June 29th. 1801.

I find from an entry in the *Gentleman's Magazine* of that year that in July, 1777, Capt. Hugonin, of the 4th or Queen's Own Dragoons, was married to Miss Charlotte Edgar, of Redhouse, in Suffolk, the writer of the following letters; and, from an entry recording the death of the youngest daughter of Colonel Hugonin in June, 1799, that they were then residing at Nursted House, near Peterfield, Hants. The reference to Major General Hugonin, of Barnard Castle, is apparently to Major General James Hugonin, who died at that place in 1818, aged 88. The husband of Colonel Philips's correspondent was Colonel Francis Hugonin, who was gazetted Major General in 1803, the year after that in which the second of the two letters was written. The allusion to Colonel Philips's "beautiful garden" and his civility to Colonel Hugonin, suggests that the residence at Mayfield was, in the words applied by Washington Irving, to Roscoe's in Liverpool "the seat of elegant hospitality." The list of plants at the foot of Mrs. Hugonin's second letter apparently describes the contents of the hamper sent to Mayfield by her. The *Erica ciliaris*, which Mrs. Hugonin did not consider to be British, is, Mr. Charles Bailey writes me, a wild Cornish plant* :—

Nursted Nov^{br} 15th
1801.

Sir

I received the Basket of plants yesterday morning in perfect good order. They are all planted according to your directions & do not look at all the worse for their journey. I beg you will accept my thanks. The Azalea procumbens will have my particular attention, as Sowerby had taught me to admire it. Never expecting to meet with the plant, it is a great prize to me. The primula's are all great favorites—except the farinosa, they were strangers to me. Erica ciliaris, & Cornus Canadensis, I cannot consider as British.

By the number of British plants you have sent me, I must consider you as a great Botanist, this part affords a greater variety of soil than any part of England I ever was in, and in my Botanical researches I had the good luck to meet with many very rare plants—almost all the Orchis's, and many Ophrys's. Serapias ensifolia, grandiflora, latifolia, longifolia. Campanula patula which Dr. Smith mentions as one of the rarest English plants. I hope if you wish for any of the above next year you will employ me. I had the Cistus guttatus and Salicifolius blowing in my garden very beautiful all the Summer. Should you not have them I can save you some of the Seeds. I have lately purchased a great variety of British plants from Salisbury's Botanical garden at Brompton (late Curtis's) and a few green House plants, amongst the latter three Lobelias that are great ornaments to the House being always in blossom. Lobelia Denticulata, pubescens, & Bicolor. It is almost time to mention the Colonel who arrived at Nursted last Tuesday perfectly well—he is continually talking of your civility to him, and of your beautiful garden—he holds my garden & knowledge of plants extremely cheap after having seen yours.

Colonel Hugonin begs to join me in best comp$^{ts.}$ I am Sir

Your obd^{t} Humble Serv^{t}
CHARLOTTE F. HUGONIN.

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* I may remind the reader that in the use of capitals in the botanical names and in all other details, punctuation, italicising, and so forth, I have in the reproduction of Mrs. Hugonin's letters, as in all other instances, considered it best to faithfully follow the manuscript.—F. J. F.

Nursted House
June 23d 1802.

Sir.

It affords me great pleasure to think that I can in any way contribute to your collection of plants. I hope you will receive a Hamper Safe, that is gone to London by this night's Mail; as we took up the roots with great care, I hope you will save them all. Ophrys Apifera is the only one I am afraid of, they grow about us in the hottest places liking short grass to grow round them. The *Monorchis* is so small that it is likely to be overlooked in taking out the moss—there are three of them, packed by themselves, upon the top—great care should be taken that the Bulbs of the Muscifera and Apifera should not be broken. I may possibly have sent you some plants that you may have growing near you. They are great favourites of mine, & I think a wood cannot abound too much with them. I shall be anxious to hear of the arrival of the Hamper. I leave my peaceful abode the 5th of next month, to join the Regiment, should you not receive the plants in time for an answer to find me here pray do me the favor to direct to me at Majr Genl. Hugonin's Barnard Castle. A Clergyman in this neighbourhood, a friend of ours, and a good botanist, is so obliging as to take the charge of my flowers & plants during my absence. Should you wish for anything that this country affords he requests you will inform him: his addess is, Revd. W. S. Bayton Nursted.

The Winter and Spring was very unfavourable for the young plants you was so kind as to send me. The Azalea procumbens looked green the whole winter, but did not grow, and appears now in a very sickly state. Pray inform me how you manage to keep it.

I expect to find many curious and scarce plants in the North. The Colonel has been with the Regiment since the 10th of March.

I am Sir
your obedt Servt
CHARLOTTE F. HUGONIN.

Serapias
—latifolia
—ensifolia
—grandiflora

Orchis
—bifolia
—pyramidalis
—conopsea

Ophrys
Monorchis
Muscifera
Apifera

The following memorial relates to Mr. Philips's public work as Treasurer of the Royal Infirmary :—

April 23rd 1804.

To John Leigh Philips Esqe.
Sir

We the under-signed Trustees of the Infirmary Dispensary Lunatic Hospital and Asylum in Manchester, being greatly concerned at the Notice given in your Letter to the Quarterly Board at Christmas last, of your intention to resign your office of Treasurer to these Charities, and being very apprehensive of injury to them if you persevere in that intention, do hereby most earnestly request your continuance in that Office. You have held it long, with great honour to yourself, with great benefit to these noble Institutions, and with great satisfaction to the public. We are sorry that any circumstances should have arisen to induce you to form such a determination. And, fully convinced that you have no object in view but the welfare of these important Charities, We hereby engage, as far as in us lies, to give you our firmest support, as well as our most grateful acknowledgements—in the fixed confidence that you will still continue to display the same energy, ability, and faithfulness, which we have hitherto witnessed in your discharge of that important Office.

Rowland Broomhead
J. Whittenbury
Rich^{d} Barlow
Charles Fred Brandt
Jas. Aikin
Thos. Robinson
Robert James
John Tetson
Thos. Barnes
Thos. Harris
John Stonehouse
Jas. Hibbert
John Leaf
John Kearsley
James Touchet
Robert Peel
Chas. Wood
Jonath^{n} Beever
Wm. Wright
William Beever
Ed. Kenyon
Jas. Potter
Francis Rush
J. Silvester
Wm. Douglas
Thomas Hilton
Thos. Henry
Henry Barton
John Barton
John Trafford
John Clowes
C. White
Thomas Darwell Sen^{r}
Jos. Ablett
Dauntesey Hulme
Rich$^{d.}$ Potter
J. Dickenson, Birch
Sam$^{l.}$ Mather
Wm. Cooper
Francis Reynolds
Roger Holland

The requisition which follows was apparently elicited by the circumstances out of which arose the attempted duel between Philips and Hanson. The hostile meeting was to have taken place on July 25th. The dispute arose out of a question of precedence, which Philips and his officers claimed on the ground of his longer military experience, he having previously commanded a larger body of men than the new corps formed about this time; while Hanson claimed it on the technical ground of priority in the date of his commission. Hanson, who was born in 1774, was, it should be pointed out, much the younger of the two men. The point was settled at head-quarters in favour of Hanson, whereupon Philips resigned his commission, and all the officers under his command followed his example, declining to serve under any other leader. Their testimony of Philips was that "he made discipline engaging and authority amiable." The regiment was, therefore, disbanded. Possibly the feud between Philips and Hanson may really have had an earlier origin, and have been to some extent a consequence of political feeling. Philips appears to have retired from the Manchester Literary and Philosophical Society somewhere about 1792, and Hanson was elected a member in 1794. The sympathies of the latter were entirely on the democratic side. The two branches of the Philips family appear to have drifted into opposite political opinions; in 1792 George Philips, who was made a baronet in 1828, published a pamphlet entitled "The necessity of a Speedy Reform in Parliament," in the composition of which he is said to have heen greatly assisted by Dr. Ferriar. The tendencies of this branch of the family eventually found an expression in the politics of Mark Philips, while those of the branch to which Colonel John Leigh Philips belonged appear to have culminated in his younger brother and partner in business, Francis, a sturdy opponent of reform, and an unswerving Protectionist. It may have been the growth of such divisions which prompted Dr. Samuel Argent Bardsley to read before the Society, in 1794, a paper on "Party Prejudice." The following memorial appears to have been presented to Philips after the disbanding of the regiment in consequence of the preference given to the claims of Hanson:—

John Leigh Philips Esquire and the Gentlemen who were Officers in the 1st Regimt of Manchester and Salford Volunteer Infantry.

Gentlemen

In contemplating with Pleasure the Zeal and Discipline, which the Officers and Men of your late Corps so honorably manifested, We cannot omit expressing to you our Regret that the Services of this valuable Regiment should at the present Moment be lost to the Country.

The vigorous Measures recently taken to encrease the defensive Force of the Kingdom, and the unceasing Vigilance and active preparation now pervading all the Departments of Government are strongly indicative of the threatened Invasion being immediately attempted.

We therefore beg leave to express an anxious yet confident Hope that a Crisis, so highly important, will not fail to act as a powerful Inducement with you again to stand forward in the Defence of your King and Country.

These Sentiments, We trust, will be attributed purely to a Regard for the

Public Welfare, and to the Anxiety we feel for the Honour and Interest of these Towns at a Time when our best Energies are required.

We have the honor to be
With much respect,
Gentlemen,
Your most hble & obt Servts

Manchester,
25th September
1804.

Willm. Fox
B. A. Heywood
Edwd. Hobson
Saml. Jones
David Locker
Scholes Birch Lt. Col. N.U.F.V.
Richd. Rushforth
Willm. Jones
Jos. Thornberry
Robt. Riders
Edwd. Chesshyre
Jo. Ablett
Saml. Stocks
Richd. Potter

Benj. Potter
Will Ollivant
John Kearsley
Richd. Biarlow
W. Robinson
J. Norbury
Wm. Cooper
Otho Hulme
Charles Fred Brandt
Saml. Argent Bardsley
Dauntesey Hulme
H. Gill
Saml. Peel
J. Gould

Geo. Gould
Robert Markland
John Riding
Heny Barton.
John Barton
Roger Holland
Isaac Ablett
John Tetson
Falkr. Phillips
J. Whittenbury
Richd. Ollivant
Thomas Darwell
William Heywood
Thos. Tipping

The following letter again brings before us Colonel Philips's sporting proclivities. The brother in question was the Mr. Francis Philips, alluded to above, the fourth of the sons of John Philips, of Bank Hall. He was born in 1771, and died in 1850. He was the author of a pamphlet, "Murder is Out," published in 1809; "Johnny Shuttle and his Cottage; a Tale interesting to the Inhabitants of Manchester," also published in 1809; "Exposure of the Calumnies against the Magistrates and Yeomanry," published in 1819 (the Peterloo year); and, later in life, "A Treatise on Turnpike Roads," published in 1835. In 1792 he married Beatrice, daughter of James Aspinall, of Liverpool. It was into his arms that Perceval, the Prime Minister, fell when shot by Bellingham in the lobby of the House of Commons. His elder brothers being dead, he succeeded to his father's Bank Hall estate, by will, on the death of that veteran in 1824. He had previously resided at Longsight Hall. He was a noted agriculturist, and Deputy Lieutenant for Cheshire. Stockport was much indebted to his liberality. He took a prominent part in the erection and management of the Stockport Infirmary, and in the construction of Wellington Road:—

Rydall Mount near Kendal
19th November 1805.

Dear Sir,

The Woodcocks are arrived in this neighbourhood, but on account of the very fine weather that we have had, & which still continues, very few are yet come down into the Woods, but they are numerous upon the tops of the mountains. Many have been taken in Sprints, but only a few shot. If you will come over and try your hand amongst them I shall be truly glad to see you—bring your dogs along with you; I had but one, & he is lately dead. Will you be kind enough to present my best respects to your brother Francis, & tell him that I shall also be extremely happy if he will accompany you, but should it not be convenient for him to be from home at the same time that you are I shall be very glad to see him when it will best suit his convenience. My accommodations are not yet so good as I could wish, because we have not yet got our furniture from Lancaster, but we have a couple of spare beds, & I will endeavour to make our Cottage as comfortable to you as Circumstances will admit of. We are much inconvenienced here by the scarcity of Workmen—being at so great a distance from any large town. Mrs. North joins in best respects to yourself Mrs. Philips & all our friends with

Dear Sir
Yours truly
FORD NORTH.

In the following letter the engraver, James Heath, alludes to the picture of the "Death of Nelson," painted by Benjamin West. Mr. Philips was one of the first subscribers for the proof engraving. The library referred to was apparently the Portico in Mosley Street, which was opened on January 20, 1806:—

Jany. 25. 1806.

Dear Sir

I recd your Letter and the Velvet which Mrs. Heath likes very much and wishes to know the price. I have written to Mr. U. Zannetti and I have put his name down for 2 early Impressions, our Proof Subscription being full. I have the pleasure to inform you that we shall have the greatest number of

Names ever known. Mr. West is very forward with the Picture which is the finest I ever saw in my life. The Wolfe is nothing to it. Respecting the Books for your Library, my Son will undertake it for the first year and if there is no more trouble than appears upon the face of it he will continue it as long as you please. I admire the Scheme and think it worthy the people of Manchester who are acknowledged to be the most liberal and enlighten'd of any people in England. There are two more Vols. of Shaw just publish'd which I have ordered to be sent to you. I have likewise sent Ackermans' print by the Coach this evening. Nothing is talk'd of here but Mr. Pitt's death, but it is not as it would have been if he had died a few years ago. Nelson was the lucky man, he died in the very moment a wise man would choose. I am

yours truly

J. HEATH.

Russell Place.

The writer of the next letter which I have selected was William Martin, an English historical painter, a pupil of Cipriani, who obtained a gold palette from the Society of Arts in 1766, and exhibited at the Royal Academy from 1775 to 1816. He was employed by George III. to do decorative work at Windsor Castle. The new library building referred to is again evidently the Portico:—

My Dear Sir

When I last visited Manchester, about eighteen months since, I was very much struck with the Elegance and simplicity of a building, then going forward, which I afterwards heard was intended for a public library. About seven years since Designs were made, (In this Town,) and fully approved off, by the National Council, For A Splendid building, Intended for the Use of the Two Legislative Assemblys, & as it appeared that the same was Decided on being carried into execution I employed, many years study, in executing several large, & appropriate, Pictures (from the life of Alfred the Great), for the purpose, of presenting them, to assist in the Internal Decoration but as the Plan of carrying that building into Execution has, & most probable, will remain a sleep, I have determined on dividing this Work & have presented One of these Pictures to the University of Oxford, One to the University of Cambridge and One I have to request you will offer (from me) to the Proprietors, of the building I have alluded to, provided they have a sittuation calculated to receive it—Its size is twelve feet high & ten wide—the subject is the before mentioned great Monarch, during his concealment In the Island of Athelingny in Somersetshire—the Point of time represented is the vision of St. Cuthbert appearing to him—Alfred is stated to have fallen a sleep (when reading) when this Vision presented its self before him & Related that the Time was now arrived when it was the Divine will, he should be Reinstated in the Government of his Kingdom.—*Vide* Spelmans Life of Alfred.

Yours most truly,
WM. MARTIN.

June 13th 1806
Leigh Philips, Esq.
Mayfield,
near
Manchester.

P.S.

As I shall remove a little way out of London very soon, you will please to direct your answer to This, to me at Mr. Betts, Dean Street, Soho. I hope this will find you, Mrs. & Miss Philips arrived safe at Mayfield and that there was no Impediment to their seeing Frogmore which I am certain would greatly entertain them—you will please not to forget me In case that matter remains vacant at your library.

The following letter seems to indicate that Mr. Philips was interested in the establishment of a "Hospital Sunday" for the benefit of the Infirmary. The letter is not without interest in connection with the Moravian settlement, originally established at Fairfield about 1775 :—

Sir

Through Mr. Eadon I am favoured with a notification of the wishes of the board of the Manchester Infirmary &c. that a sermon may be preached in our chapel the Sunday preceding Easter & beg leave to say in answer, that it will give me & our people generally much pleasure to promote in this or any other way the interests of these valuable Institutions & tho' from the smallness & character of our congregation, being chiefly poor people, our ability is very limited, it will not I hope on this account be a less acceptable offering.—I am respectfully

Sir
Your faithful servant
CHRISTIAN GOTTHELF IKE
Minister of Fairfield Congrn.

Fairfield, Febry. 10th
1808.

The writer of the following letters was also one of the most illustrious members of the Society, Dr. William Henry (who was elected a Fellow of the Royal Society in the year in which the letter was written) the father of Dr. William Charles Henry, whose name is still included in our list of members. The eminence of the writer gives weight to the testimony they bear to the high character of Mr. Philips:—

Saty. Afternoon
(March 20th 1808)

Dear Sir

You have probably learned from Dr. Dewar his intention of resigning at the Infirmary on Monday. Immediately on receiving the information I called on Dr. Winstanley to ascertain whether he intended to begin his canvass immediately, or to wait for the formal announcement which Dr. D. intends to make at the board. He was not, however, at home; but I was informed by Dr. Hull, that, seeing no impropriety in the immediate application for votes, he had advised Dr. Winstanley to take this step without loss of time. Being of the same opinion myself, I immediately began my canvas, and have called at your compting house (from whence I write these hasty lines) to notify my intention to you. Your vote I do not think it proper to ask; because you will probably not declare in favour of any candidate. On your good wishes I hope and believe that I may rely.

I am, Dear Sir,
Yours with much respect
WILLIAM HENRY.

Dawson Street
Thursday afternoon
24 March. (1808)

Dear Sir

Though it is perhaps not strictly necessary to trouble you with any reply to the official note, with which you have favoured me, yet I cannot deny myself the gratification of thanking you, very sincerely, for the friendly interest you have taken in my behalf, as far as was consistent with that impartiality, which the welfare of the charity and your peculiar situation as its principal officer required. For your handsome conduct at the board, of which I hear from all quarters, I feel peculiarly grateful.

Believe me, most respectfully,
Dear Sir, Your obliged and humble servt.
WM HENRY.

Mr. Philips's interest in the engraver's art apparently led him to take part in opposing capital punishment for forgery. The following letter is an expression of the growing public feeling which ultimately compelled the repeal of a barbarous law. The writer was John Landseer, the father of Sir Edwin Landseer, who was born in the house from which the letter was addressed.

John Landseer was a line engraver. His earliest work was the illustration of Macklin's Bible, but subsequently he devoted great attention to engraving animals after the old masters, an occupation which no doubt gave a bent to the genius of his more famous son. He was elected an Associate Engraver of the Royal Academy in 1802, the year of Sir Edwin's birth, and died in London in 1852:—

Queen Ann's St. East 12 Sept^{r} 1809.

Dear Sir

I too have been in the country for the last fortnight for the benefit of my health (being troubled with a *giddy head*,) and have just now met your letter on my return. I cannot at present write so much at length as I should wish, having just at this moment many demands on my time—tho' my absence has been but short.

I very readily enter into correspondence with you on a subject which (since I attended at the Bank, where I witnessed enough of Mr. ——'s effrontery) has engaged no small portion of my attention. You may see that I had it in mind when I read my friend Lutrin, where the rub at p. 68 was intended for the more particular notice of a Bank Director who is also a director of the Royal Inst.^{n} —— I can "eat mutton cold," but cannot be for ever cutting "blocks with a razor." I have already lost much time in fruitless endeavours to remedy the existing evils, among the idle, the indifferent, the interested & the insensible, & have really been sickened to see how little they care for *what is said*, and how much they choose to be imposed upon by WHO *speaks*.

I am much afraid that your acquaintance with Bank Directors will not avail in the present case, unless it should enable you to awaken their consciences as *Men* for *as Bank Directors*, their conduct has but confirmed the assertion of Swift—or whoever else it was that said public bodies were without consciences. Have you observed that they care at all about the number of poor Devils that are hung? In one county or another, these poor sufferers must have amounted to a very considerable number, yet what single step have the Bank Directors taken to prevent such executions?

When we consider on the one hand, that these poor *tempted* men are hung for doing that which every letter Engraver's Apprentice who has been half a Year at his profession may easily do, and on the other, the public & private consequences of allowing the issue of Bank paper to remain as at present; & when we also reflect on the apathy of the Bank directors—that they absolutely do nothing to prevent the recurrence of the mischief, & seem to *indulge* Mr. ——'s fear of losing his place—what can we infer but that as Bank Directors they care only for the Credit of the Bank?

When we further consider, what you have truly stated, that they have at the Bank a secret means of knowing the true from the false notes, & that they do *not pay* the forgeries, how can we hope that an application to the Bank Directors or writing to the *Monthly Mag:* will avail?

I should have much better hopes from an application to Parliament, and if you should agree with me that the wise step would be to look the evil steadily in the face, & instead of proposing expedients to go to their principle & to Parliament, I shall he happy to co-operate. I have for some time had thoughts of speaking to Sir S. Romilly, whom I have the honour to know, & who I think would be a very proper person to bring the business forward, on the subject. I presume you would have no objection to my shewing him your letter;—meanwhile allow me to express my wish that you would recal for the present what you may have sent to the *Monthly Magazine.*

With respect to Proofs of my engravings—I have been inattentive, I confess—but I really thought I had sent you some, since the time you mention. —Surely I have.—When I am able to look up a few, How should they travel?

I rem$^{n.}$

Dear Sir very Sincerely Yours

J. LANDSEER.

The following letter again indicates Colonel Philips's interest in colour materials and his activity as a practical horticulturist:—

Carham, Dec. 1809.

Sir,

Having observed in my *Monthy. Mag.* for Nov$^{r.}$ that you possess plants of the Smyrna Madder from seeds of your own importing, and having paid much attention for several years past to the growth and qualities of the common dutch kind partly with a view to obtain a permanent colour for painting, of my success in which the following specimen will give you the best idea, I shall be extremely obliged if I may be allowed to partake of the plants you liberally offer to your friends, notwithstanding my being a stranger to you permits me only to subscribe myself,

Sir,

Your obliged Humble Servant,

J. FIELD.

Pray Sir if you oblige me with a root or two do me the favour to have them addressed for me To N$^{o.}$ 14, Clare Street, Bristol. I have not hitherto used any other than the *madder of commerce* in the prep$^{n.}$ of the colour of which I have sent you a specimen; except once by way of experiment from the *green or fresh root* of my own growing, the result of which differed very little from the madder of commerce, and I have obtained colour from our *native wild madder,* but inferior to the others.

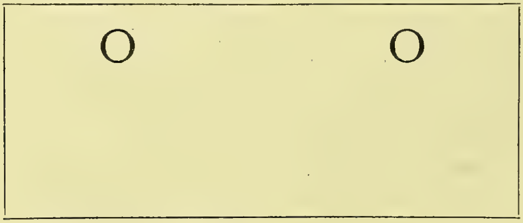
Mr. Philips's communication to the *Monthly Magazine* on the subject of bank-note forgeries elicited the following letter to him, written, it will be observed, about a year later than Landseer's. The writer, Thomas Cooper, M.D., the well-known materialist, was elected an honorary member of the Manchester Literary and Philosophical Society in 1783, and an ordinary member in 1785. In 1792 he and James Watt, Junr., being in France on private business, represented the Manchester Constitutional Society as delegates to the Jacobin Club. This Watt, it may be observed, who was co-secretary with Dr. Ferriar of the Manchester Literary and Philosophical Society in 1789 and 1790, was the son of the Watt of steam-engine fame, and was apparently agent for his father's business in Manchester. Cooper and Watt learned the secret of making chlorine from common salt while in France, and the former subsequently settled in Manchester as a bleacher and calico-printer. Later on he followed his friend Priestley to America, and became a judge in Pennsylvania in 1806. In 1811 he was appointed Professor of Mineralogy and Chemistry in the University of Pennsylvania, and at a later date Professor of Chemistry in South Carolina College. It will be observed that the letter to Philips was written while he was still filling the position of judge, and that it describes his entering on the study of mineralogy, of which he became a teacher in the succeeding year. The allusion to the father of Colonel Philips helps to complete our biographical sketch. The Tom Kershaw referred to is frequently mentioned in the letters. Like Philips he was a member of the Society in its first year (1781), and was also on the "Committee of Papers." He was the author of a paper published in the first volume of ths *Memoirs* "On the Comparative Merit of the Ancients and the Moderns with Respect to the Imitative Arts." Cooper, who was a Vice-President of the Society from 1786 to 1791, also contributed to the *Memoirs*. It is worthy of note that several of Colonel Philips's brothers proceeded to Pennsylvania; Henry died in Philadelphia in 1800, and Hardman Philips, resident at Philipsburg, died in 1854. Another brother, Nathaniel George, died in New York in 1793. A cousin of Leigh Philips', Nathaniel, son of Nathaniel, the before-mentioned brother of John Philips of Bank Hall, also resided in Philadelphia:—

Northumberland, Pennsylvania
August 25. 1810.

Dear Sir

I have read with great pleasure, your observations in the Monthly Magazine on the most effectual method of preventing counterfeit bank notes. The multiplicity of the Paper-Money Manufactories called Banks, in this Country has occasioned a number of counterfeits; and I have had to send about half a dozen of the Counterfeiting gentry to jail within these six months. I have dissemeninated your Ideas as far as I was able, but I do not find that there is as yet any motion made to unite on the face of a note so much talent as will effectually prevent the frauds that have been committed.

In the New England States, they adopt a peculiar species of engraving on Steel, which may probably answer the purpose for a time. In this State, an ingenious engraver of the name of Murray has proposed a mode of preventing counterfeits, by making parts of the plate moveable which are struck off in different colours; somewhat in this manner:



The round spaces are parts of the plate separated, but fitting exactly when inserted in their places. The colours of the Ink may be varied at each impression. I think it will be adopted. Should any more feasible plan occur in England I fancy there will 'ere long be a disposition to adopt it here.

I observe also in the Monthly Magazine a notice from you on the introduction of the Smyrna Madder. That Plant and The Wild (Reseda Luteola) would certainly succeed well here, and might be made an article of profitable export. I much wish for an Opportunity of trying them, and know of no person so likely as to render me assistance in this respect as yourself. I should hold myself very much obliged to you, either for a few seeds, or (if you think they would grow) a few plants of the Smyrna Madder. In about half a Century we may perhaps commence manufactures here, but as yet our progress in that way is little more than family manufacture, and our business is to export the raw and import the manufactured material. We have as yet neither hands sufficient, nor capital enough, nor knowledge enough to interfere with you in any way worth notice. People are trying in various places, but the attempt to meet you in the Market is out of the Question.

I write to you little about the Politics of this Country. It may be comprized in a few words; with respect to our foreign relations, we have no means of engaging in war or inflicting injury on those who injure us. Unless by an Embargo, which is so much evaded, that you hardly feel it. Indeed, the People here are really averse to a quarrel with Great Britain; if we can maintain peace we are determined to do so, & to overlook small injuries. But it will not be policy to force us into self-defence. Everything here is in a way of improvement full as rapid as at any period in England, considering the great disparity of resources in the two Countries. At present, at the Intervals of my professional Avocations, I attend to literary pursuits as formerly. I am studying Mineralogy furiously. I dream of Stones every night from the Actinolite to the Zeolyte and the Zoisyte all through the Alphabet. Nothing would delight my eyes more than one or two hundred weight of minerals and fossils. If I knew how to smuggle them, I would most gladly make a remittance in the best Havannah Segars; but in the midst of all your pursuits, I fancy you have left out Mineralogy.

If your good father be alive, tell him I think with kind and respectful feelings of our Conversations and his correcting my greek quotations. Be assured that at no day have my former friends been unrecollected with grateful pleasure. If you can communicate any scientifical or cognoscentical Information you will do me service. In this Country my old friend Tom Kershaw's classification is not quite applicable. We are not divided into the Cognoscenti the Cognoscentini and the Ignoranti, we humbly submit to rank ourselves under the two latter Denominations. You will however always oblige me by ranging me as Amateur in any pursuit that relates to knowledge of any kind. Say to my friends, I do not forget them, altho' I seem to be forgotten. Adieu

I remain yr friend

THOMAS COOPER.

Any parcel sent to me to the care of Mr. John Vaughan Philadelphia, will reach me.

We get a glimpse of Philips as a boy from the following letters, as well as additional testimony to his activity on behalf of the Manchester Infirmary. The writer was Captain Joseph Budworth, who was born in Manchester in 1759, and was, therefore, about two years older than Philips, his father being the landlord of the Palace Inn. He was educated at the Manchester Grammar School, and served as a lieutenant in the 72nd, or Royal Manchester Volunteers, during the siege of Gibraltar. In the introduction to a poem composed in September, 1782, during the siege, and published in quarto in 1795, he tells us that, though only twenty-one at that time, he was the oldest man in his company. He was given to poetry, and in the "Fortnight's Ramble to the Lakes," referred to in the following letters, there are not only verses descriptive of an ascent of Helvellyn in 1793, but others composed in a friend's bungalow in Bengal, whither he proceeded with his regiment, in 1784. The "Fortnight's Ramble to the Lakes" is perhaps best remembered as having contained the first description of the famous "Beauty of Buttermere." For the sake of our local literary credit I may be permitted to quote the passage, which, written immediately before the era of the Lake Poets, is not unworthy in its elegant simplicity of the pen of the author of "The Doctor":—

> "Her mother and she were spinning woollen yarn in the back kitchen. On our going into it, the girl flew away as swift as a mountain sheep, and it was not until our return from Scale Force that we could say we first saw her. She brought in part of our dinner, and seemed to be about fifteen. Her hair was thick and long, of a dark brown, and, though unadorned with ringlets, did not seem to want them; her face was a fine oval, with full eyes and lips as red as vermilion; her cheeks had more of the lily than the rose; and although she had never been out of the village (and I hope will have no ambition to wish it) she had a manner about her which seemed better calculated to set off dress, than dress *her*. She was a very Lavinia,
>
> Seeming, when unadorn'd, adorn'd the most.
>
> When we first saw her at her distaff, after she had got the better of her first fears, she looked an angel; and I doubt not but she is the reigning lily of the valley. Ye travellers of the Lakes, if you visit this obscure place, such you will find the fair SALLY OF BUTTERMERE."

Some years later poor Mary obtained increased notoriety in consequence of the cruel fraud practised upon her by a fugitive from justice, John Hatfield, who, representing himself to be the Honourable Colonel Hope, brother of Lord Hopetoun, obtained her hand in marriage. Shortly afterwards the imposter was apprehended, and executed at Carlisle for forgery on September 3, 1803. After his marriage with an Irish heiress, Miss Palmer, of Palmerstown and Bellingham Lodge, on February 27th, 1787, Captain (then Lieutenant) Budworth added the name of Palmer to his own, though it will be observed that in the following letters he retains his old signature. His daughter Emma married William Alexander Mackinnon, Esq., of Mackinnon, and two of her daughters became respectively Countess of Dundonald (wife of the eleventh earl) and Duchess de Grammont. The Manchester innkeeper thus became the ancestor of earls and dukes. Captain Budworth was a Fellow of the Society of Antiquaries. He died in September, 1815, fifteen months after the death of his old playmate. It is uncertain whether the allusion in the letters implies that Philips and Budworth actually attended the same school; if that is the meaning, either Budworth was for some time at Henry Clarke's school in Salford, or Philips was for some time at the Manchester Grammar School. The George Hibbert alluded to was apparently Alderman George Hibbert, of London, F.R.S., F.S.A., who was the son of Robert Hibbert, constable of Manchester in 1759, the year of Budworth's birth. The letters contain some interesting details of Budworth's experiences as a soldier, and as an author:—

My D^r^ Sir

I would have answered your kind Letter long ago, if I had not meant to do it more substantially than by words.

Hearing that the Funds of the Manchester Infirmary were very low—I sent to you a small recollection—But never losing sight of it, waited until my plan approached maturity and which being nearly the case—shall briefly take the liberty of opening it to you:—for my good Sir in return for your friendly recollection of me—I have the pleasure of saying I remember you—when our days were few—and our native Town contained everything dear to us.

In August 1792 I made a Fortnight's Ramble to the Lakes—published it in Nov^r^ and in Jan^y^—the Sale having cleared every expence and as it was slovenly—I discontinued it. In 1795 a 2^d^ Edition came out corrected (1000 Copies)—500 or more perished at a fire at the Printers two Years ago—and the Book is now literally out of print—and understanding it is in request, and having leisure; I am bringing out 250 Copies chiefly to keep it alive—and as the Reviews spoke well of it and as an Author must be proud of existence—I follow it up, with such material additions, as gives it the features of an almost new Work:—Thus improved, I request leave to present *the sole emolument* arising from the Tale *to the Charities*, of w^ch^ you are The Treasurer, and to w^ch^ my Father was a very early subscriber—and for the effectually doing it every expence is already settled with Mess^rs^ Jno. Nichols and Son, my friends and the printers; and when the Book is out, I shall direct *Cadell* and *Davies* to transmit to you, what money the Sale produces—the price will be about 8/^s.^

Allow me to trouble you with a Commission to procure a Booksellers Name in Manchester—as a few Copies may probably go off there. What think you of *Joseph Aston*—printer of the Manchester Guide? wch open'd Wonders to me—since I was an inhabitant—besides page 75—the manner the Old Manchester Volunteers is mentioned, brings home the most clinging associations in my Mind—I carried the Kings Colours of that glorious Regt the Day they were presented to it—I was christened at the Altar above which they are deposited—and under that sacred Building my beloved Parents rest.

You good Sir whose heart is in Unison with sound feelings can conceive, what mine must be—

I am Dr Sir
Your faithful townsman and friend
JOS. BUDWORTH.

Clifton, Bristol
March 30th 1810.

The Book will be out about May—and it will give me great satisfaction—if you could spare time to look at it when published—it presumes not in any literary shape—simplicity and sticking close to characters—are its features—those it is acknowledged to possess—and an after excursion furnished more materials, whch will enlarge The *Infirmary Edition*—and we Trust the Production will be no discredit to the Native Town the Author is proud to have been born in—and to owe other lasting obligations to.

Clifton Bristol April 17th 1810. It is droll that this day 32 years my Lieutenancy bears date and this day 16 years my Captaincy—P.S. Can I transfer a power of admitting a patient into the Infirmary?

My Dear Sir

I truly received satisfaction by the receipt of your kind Letter—and I cannot help looking with fresh astonishment at the Subscriptions and Donations added to the Funds of the Infirmary. You are an active People—and must individually have put your Shoulders to the Wheel, and made use of good arguments to double the *2 Guinea* Subscribers wch were partly considered as heir Looms in familys;—occasionally seeing a Manchester Paper, I saw the Mine was working well—but I had no conception the Sums produced could have approached by many hundreds a year the liberality you have so much favour'd me by stating—and I am sure you, both as its Guardian and Friend, have been a material part, to bring all This good about—indeed I *had heard* so.

I was not in the least surprized to hear you spoken of, as I am proud to tell you I have both by your Townsmen and Others—I well remember the activity of your mind when you were a very little Fellow—and I will honestly tell you—that George Hibbert and you made more intellectual impression than any of my earliest townsboys—George and I were like Brothers and I owe very much to the assistance I received from his manly mind;—he used to assist me in my exercises—and what was more, made me understand them; he marched with me in the Regt. to Altringham—came to see me at Portsmouth

—and sent me a large supply of Cheese Ham (and what was a treasure to a Lancashire Man) of potatoes to Gibraltar—We were at one time inseperable, and all those associations of the head and heart were known to each other wch so sweetly cling around early impressions. I saw all the efforts of his Muse—and he was the first to encourage mine—I had been five years at a wretched School—and 'twas he who put me in the path to bring up somewhat of my learning ; he insinuated information with such kindliness, as if he had not felt himself my superior—but every thing he said and did proved him so much so that while I loved him as a Brother I revered him as a Man.

Now we never see each other—he in the midst of a large family is emmerged in Commerce and Politicks in the midst of wch early times are swallowed up—and what we used to call "*Manchester Days*" seldom come across the Merchant :—yet—and happy it is as the Evening of life comes on when a happy home is the Compass of the Soul—but yet old days should not be altogether expelled. I am a keen sportsman in thinking on the past, and my memory is so tenacious in trifles that I remember the faces and Conversations of every Boy I liked at School—and though you were years too young to associate with Hibbert and me, he knew you well, and I never spoke to you that I had not a droll answer and from wch my Dr Sir, I class'd you in my mind as a Boy, we might expect to hear something of.

Mentioning George Hibbert made me launch out a longer Lr. than is reasonable—but though I shall probably never see him again his name acts like electricity upon me.

If you should see the third Edition, you will find much extraneous matter—and indeed some quite unconnected wth the Lakes—and even some grievances as a Soldier and a *Manchester one*, too, is lugg'd in—they have been long bottled up, and as I shall probably publish no more, and as the Ramble has already exhibited symptoms of outliving me, I could not resist introducing the neglect the Regt. experienced and how heavily it fell upon me ; in doing wch I have kept as clear of Self as possible, but have the goodness to recollect if you should think there is a spark of egotism that I never mention myself but when necessarily speaking of another—and I unbosom myself so far to you as to mention ; the Historian was with me when I recd a wound that *ever* tyrannises over me—had he mentioned my behavior at that time and at the hospital my fortune would have been made in India—I would have done it to him.

Before I went a 2d time to India, speaking to him abt. some Officers who from the service they did to the Garrison shod have been named—and I then hinted the use he might have been of to me—He said "where all behaved well he had not particularized any—and had I died of my wound such would have been done"—*I was glad to say I was alive.* I then only thought it unkind but having a daughter and being of humble Birth it wd have been satisfactory (had it appeared in its proper place) to * * * * * —Believe in truth

I am your Friend and townsman,

JOS: BUDWORTH.

I would not delay ans. & excuse repetition of Words as I have not time to write it over again—and I think you entitled to a quick ans$^{r.}$ It may be some years before the Edition is sold—and when done, it will produce £100.

It was our Townsman Ridgway by his promptitude saved many hundred Barrels of flour when in the midst of Conflagration—and who I say ought to have been named—after which "*etcetera &c*" means when I was wounded and a *recollection*—sho^{d} my Book reach the historian's hands.

Dear Sir

Indeed it is an everlasting Credit to the Town, and those Gentlemen who have drawn forth The Subscriptions to the Infirmary—and I thank you for the List I received through Mr. Walton. Having a little flush of money I had the satisfaction of bringing out a 3^{d} Edition of my Ramble, published for the Infirmary. Many Copies have sold at Bath and Bristol—but I am somewhat surprized to learn from my Booksellers, that not one Copy is gone to Manchester. So truly is it verified "that a prophet is of no avail in his own Country." However I trust in a few years the 250 Copies will go off and that your useful charity, will be a little benefitted by my good intentions—I am with respect

D Sir

Your faithful Townsman,

JOS. BUDWORTH.

Clifton Bristol
Nov^{r} 8th 1810
J. L. Philips Esq^{r}

My Dear Sir

I had the satisfaction of writing to you yesterday and enclosing a Bank Post Bill for the use of the Manchester Infirmary. I was on a visit to our townsman Mr. Thos$^{.}$ Chadwick at hampton when the Note was sent to me; he was talking and the Post waiting while I wrote; it strikes me I directed to you as Secratary instead of Treasurer, and w^{ch} mistake is The reason of my troubling you wth this Letter, and is my apology.

I take the opportunity of saying in consequence of repeated misunderstandings between the Surgeons and Committees of the Bristol Infirmary that salutary Institution was often, and particularly lately, a scene of discordance; and in consequence, Mr. Birch who had long been the Treasurer resigned, and a meeting of the Subscribers being called, a heavy and just censure was passed on two of the surgeons, and after Mr. Birch explaining his reasons for giving up his situation Debates ensued, the Surgeons apologized and Mr. Birch's conduct receiving decided commendation, he was earnestly and respectfully requested to reassume the situation; so called upon, he in the handsomest manner reaccepted it, but under such express conditions and future regulations to be proposed as must hinder a recurrence of such circumstances as occasioned that meeting.

Altho' unknown to Mr. Birch I took with me and gave to him your wonderful report of the last year, and told him whatever I recollected of the

Manchester Infirmary. He not only received it with the attention of a Man of general humanity, but wth the highest admiration of the exertions that must have been called forth to bring into effect so unanimous, and large Subscriptions—And before I left Clifton, I learnt the Committee at Bristol had Proposals in readiness wch it was hop'd would produce a certain harmony if not unanimity in Opinions—wch is more wanted than Money—in short without it money in all employs is but a burthen.

You will be sorry to hear the same Month I gave through you to the Infirmary, the Profits of the 3d Edition of my Ramble—that * * * * * * * * * * —and we can only come in, as common Creditors. Unfortunate as it is, I am rejoiced that I had previously paid every printing expence of my Book, and I rejoice at heart, of adding through my humble Talents towards the Funds of a charity that I have long bore in mind.

The Sale has been more than I expected, and the expences not less—and more Copies might have gone off—but after being advertized I stopt the Sale in consequence of the defalcation of the Unfortunate Person * * * * * —but enough—

Mr. Chadwick looks better than almost any Man of his years but is ailing —Mr. Tom Johnson is the most wonderful for he still keeps up the appearance of youth and steps with alacrity—I cannot keep up with him : he is at present at Bath and it is a great pleasure to keep up an intercourse wth two good old Manchester Stocks—who were Beaus when we were Boys and to speak as a Lancashire Man, are still *farrantly*.

I am Dr Sir Yours most faithfully
JOS BUDWORTH

London 240 Oxford St
Jan 25th 1811

The closing years of Colonel Philips's life seem to have been to some extent clouded with controversy and disappointment. We find him successively resigning the various public positions which he held. He appears to have complained bitterly of the decline of local public spirit and its sacrifice to merely commercial considerations; and he seems to have felt that his own efforts for the benefit of Manchester and Salford were not adequately supported by the gentry of the neighbourhood, who, at least in his opinion, had become somewhat lethargic. The following documents relate to this period :—

Manchester April 9. 1811.

Sir.

We your Sergeants humbly submit this for your Consideration, hoping you will as on former occasions use your interest in our behalf. We Rest Confident of your opinion of us whilst under your Command, and willingly hope your regard for us is not abated. With the utmost deference we beg leave to say it was our principle study to promote to the best of our knowledge that order and regularity so necessary to the perfecting our respective Companies, and we are assured you acknowledge the same. We address you on a Subject which we intended to have done whilst under your Command, but owing to that unpleasant Circumstance taking place which was the Cause of the dissolution of our Regiment, & knowing your feelings were severely wounded on the occasion we thought it proper to defer the subject to some future period.

We beg leave to lay before you a statement of pay received by the Sergeants of Colnls Ackers and Sylvester each serving at the time we did.

To each permanent Sergeant from the Commencement of his Servitude to the termination thereof, one Shilling and Sixpence pr. day.

We humbly hope you will use your interest in our favor for past services; and be assured Sir should the exigencies of the State require our farther assistance we should with alacrity assemble again under your Command.

We are with the greatest respect Sir
Your very humble & obliged Sergeants

P. Anderton.
James Ditchfield
Charles Cowap
W. Ridings
Thos. Bradshaw
John Butterworth
Rd. Williamson
Thomas Banks
Jno. Collins
Thos. Sterndale
Wm. Birch
John Tinker.

Manchester Infirmary Dispensary Lunatic Hospital and Asylum,
General Annual Board,
20th June, 1811

Chas Fredk Brandt Esqr. in the Chair and upwards of 60 Trustees Present

A letter from J. L. Philips Esqr Treasurer to the Infirmary and Dispensary having been read
Resolved unanimously—

1st That the Board accepts with the greatest regret his Resignation, and laments the cause that has occasioned it.

2nd That the thanks of this Meeting and of the Trustees of these Charities at large are Justly due to J. L. Philips Esqr for his long-meritorious & eminent services during the space of nearly twenty years, in promoting the Welfare of this valuable institution, for his incessant endeavours to add to the comfort of the Poor, who have had recourse to its benefits, and for his Impartial Conduct upon all occasions.

3rd That this meeting fully confiding on his benevolent dispositions toward the charities hopes for a continuance of his support as well as for his Assistance in all cases, where his knowledge and experience may become necessary.

4th That these Resolutions be transmitted to him by the Chairman of this meeting, and that they be inserted in all the Manchester Papers.

CHARLES FRED BRANDT, Chairman.

Looking back at this distance of time it may be frankly conceded that Mr. Philips's dissatisfaction—he declared himself "most heartily disgusted with the conduct of the Town"—was possibly due to a difference of opinion merely on various important questions, on which his own views were not necessarily sound. Nowadays, at any rate, it is a little startling to find a Lancashire cotton-spinner opposing the admission of American cotton, as the following letter, and the accompanying copy of a memorial presumably enclosed with it show that Mr. Philips did:—

Manchester Mar 16th
1813.

My Lord,

We are desired to transmit to your Lordship, as President of the Board of Trade, a letter addressed to that Board on the subject of American Cotton. It is signed by the most respectable Mercantile houses, as well as by the Boroughreeve and Constables in their individual Capacities, but it is thought best to avoid the Confusion of a public Towns Meeting, which in this place is frequently composed of very improper persons, to give any opinion upon public Measures—This We are desired to state to your Lordship as the cause of its not appearing with the *official* Signature of the Borough Reeve.

We can assure your Lordship that in the 4 Factories which We ourselves employ, We have entirely substituted Surat for Bowed Georgia Cotton.

We remain very truly
My Lord your Lordship's faithful Servts
J. L. PHILIPS & BROTHER.

COPY OF ENCLOSURE.

The Members for the County having communicated to the towns of Manchester & Salford an Intention on the part of his Majesty's Ministers to permit the importation of Cotton of the Growth of the United States of North America by *Neutral Vessels* on the payment of an additional duty of 3d in the lb. & by *British Vessels* of 1d½, We the undersigned Merchants & Manufacturers take the freedom to state our doubts as to the propriety of such a measure, least our Silence should be construed into an acquiescence in its propriety, or even an approbation of representations that have been made either on the grounds of individual Interests or possibly of ill founded timidity.

We have great satisfaction in stating the very material improvement that has taken place of late in the manufacturing Districts of this County, in consequence of the increased demand for goods executed for the West India & Brazil Markets, arising from the improved prices of West India produce

& other obvious causes and we entertain serious apprehensions that the admission of American Cotton (unless on the express condition of the reciprocal introduction of our manufactures) would materially injure the present improved exportation, & at the same time enable the American Government to carry on hostilities against the Country with increased Vigour.

That We believe the quantity of Cotton already in the Kingdom together with the Supplies that may be expected from the E. & W. Indies and our Allies in So. America, to be amply sufficient for the Consumption of the Country without its value being advanced so as to occasion any Stagnation or Inconvenience to the Manufacturers or to the labouring Spinners.

That for these reasons, We are of opinion that the admission of American Cotton *at the Duties proposed* will be of material disadvantage to the present trade of the County & that should the price of Cotton be depressed by such admission, it would be a serious loss to the present holders of both Cotton, Twist and Manufactured Goods which have been laid in without the Contemplation of a Measure apparently calculated to strengthen the power of an inveterate Enemy, whose object it is to injure G. B. by the prohibition of her Manufactures.

From the great interest which the Agitation of this Subject has excited in the mind of the public, We can not doubt that your Rt. Honble. Board will duly appreciate its importance, & make such Arrangements as shall secure the interests of the British Manufacturer, regardless equally of the fears or misapprehensions of interested Individuals.

We have the honour to remain

Mar: 16, 1813.

Rt. Honble. Earl Bathurst, President of the Board of Trade, &c.

Had Colonel Philips survived until the time of the American Civil War, he might not improbably have contended that the Lancashire cotton famine of that period justified his early opinions as to the importance of keeping up a supply of cotton from our own possessions. That in regard to his complaint of the apathy of his fellow-townsmen he was not alone, the following letter from Richard Atherton Farington, who was a younger brother of Joseph Farington, the artist and Royal Academician, shows. Joseph Farington, it may be mentioned, was born at Leigh in 1747, and died at Parr's Wood, near Manchester, the residence of his brother (whence the letter is dated), in 1821. The letter not improbably refers to matters which led to the passing of an Act, in June of the same year, "for the more effectual administration of the office of a Justice of the Peace within

Manchester and Salford, and to provide by means of a rate, a competent salary to a Justice of the Peace acting within the said townships, and to enable the Constables of Manchester and Salford to take recognizances in certain cases" :—

Parr's Wood March 28. 1813

Dear Sir

I am sorry indeed that your praiseworthy exertions for the benefit of Manchester and Salford should be so miserably supported, and that a proper and high Sense of them should not be entertained and shown by the Gentlemen of Manchester. On Thursday I ventured to say to the Boroughreeve and Constables that the difference betwixt the 1/6 and the 1/9 was not an object of such moment as to hazard any disagreement with Salford, and that in my judgment, from the Experience I had of business at the New Bailey, the latter proportion might be considered fair, so far as related to the Transactions carried on then.

I despair of the matter going before Parliament, this Session at least, if a deputation do not wait upon Government; notwithstanding the representations which have been made they want goading. I cannot but look forward with apprehension, to what the State of the towns may be, in the event of Illness, absence, or other causes, which may prevent attendance from the very few Magistrates within reach; & I confess to you, that the Apathy and Indifference shewn (with the exception of yourself & a few others) on this occasion, by the Gentlemen in general, will weigh strongly with me, in consulting my own Ease & Comfort. I will forward your Letter to Hay by this Evening's Post. The contents of it will I think hasten his return from London. I did write to him last Night expressing my Hope of a good result from your Meeting yesterday.

I am D^{r} Sir

Your obed. hble. Servant

R. A. FARINGTON.

With the foregoing letter, written in the year preceding that in which John Leigh Philips—who had been in indifferent health for some time previously—died, I may appropriately close this first group of selections presenting a biographical outline of a forgotten Manchester worthy. Enough has been given to shadow forth an interesting figure, which, as we peruse the letters of his many friends, takes shape as a living and very amiable personality, a boy and man of bright intelligence and refined tastes, impulsive perhaps, but frank, high-minded, public-spirited, warm-hearted, loving art sincerely and nature not less. He seems to have had a zest for knowledge of all kinds, and especially a keen appreciation for the natural in art and the curious and beautiful in nature. "Mr. Kershaw tells me that you have taken leave of the arts to hunt for locusts" wrote his friend, Captain R. Dewhurst, of Halliwell, as early as 1784; but he continued to be a generous patron of the arts to the end of his life. "I entertain a high respect for the judgment and taste you are said to possess in matters of art," John Landseer wrote to him on July 17, 1798, "and am, therefore, much gratified by the favourable opinion you have been pleased to express of what I have done." And in a letter dated June 6, 1804, Sir J. E. Smith wrote to him, "I rely on your friendship in giving this letter of introduction to Captain Hardwicke, a gentleman of whose travels in the mountains of India you have, I dare say, read. I have sent to the Botanic Garden, at Liverpool, some seeds with which this gentleman has favoured me, with strict charge that they are to be divided with you. He travels now to see England. May I beg of you to direct and assist him to things worthy of notice at Manchester? Above all let him see your garden and cabinet of insects. He has brought home the best drawings ever done in India." Broad as were his sympathies, Colonel Philips does not seem to have had much faith in democratic ideas, but he may have been influenced by his brother Francis. We detect in the later letters increasing evidence of that growing estrangement between the classes which resulted in Peterloo five years after John Leigh Philips's death. Yet we find him engaged in friendly correspondence with men like Thomas Cooper, and taking a warm interest in the agitation for the amendment of the criminal laws with which Sir Samuel Romilly was identified.

As we read these letters of a century or so ago, yellow with age, but retaining a clearness of caligraphy, an expressiveness of diction, an epistolary thoroughness which is almost a lost art, they seem still fresh from the minds and hearts of the writers. They bring us into touch with a vigorous and adventurous time, when the sons of local merchants and tradesmen, and weavers from the looms, found an attractive career in the army and navy, and the advertisements of coasting vessels significantly announced the number of guns they carried. Compared with the present city, Manchester was but a small provincial town, surrounded by bogs, and, in a sense, remote even from Liverpool and Buxton. Yet it was recognised as a centre of science and of literary and artistic culture throughout the country. During the period covered by these letters it became a famous medical school; it was not less prominent in the development of chemistry and physics; and it produced a really remarkable number of successful painters and engravers. It formed academies for the diffusion of knowledge in literature, science, and art, and established hospitals and a great public library, which were undoubtedly the fruitful parents of the more numerous and extensive institutions of to-day. To that period we must trace the birth of the aspirations which have made Manchester a leader in the modern educational movement; the local love of botany and horticulture, to which a powerful stimulus had lately been given by the work of Linneus; and the traditional reputation of the city as, at least, a market for fine pictures, choice books, good plays, and good music. The philosophical spirit of the men with whom Leigh Philips associated founded our own Society and gave it, from its birth, that character and prestige which have enabled it during its quiet, unobtrusive, self-sustaining life, to give Daltons and Joules to the world. These faded leaves bring before us the cotton-spinner and merchant, the active magistrate, the friend of many soldiers who was himself an organiser and esteemed commander of the same sturdy volunteer material out of which the immortal "Seventy-second" was composed, and the financial guardian of our greatest charity, amidst his books, prints, and paintings, his trees, flowers, shells, and insects at Mayfield, as an epitome and expression of the varied intellectual and patriotic activities of the Manchester men of that remarkable period in our local history.

Ordinary Meeting, October 29, 1889.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., President, in the Chair.

It was announced that the Council had formally decided to initiate a movement for the erection in Manchester of a memorial of the late Dr. J. P. Joule, and had appointed a sub-committee to prepare a memorial to the Mayor of Manchester—requesting him to summon a public meeting to that end—and to obtain signatures to such memorial.

Mr. H. H. HOWORTH, M.P., read a portion of a paper "On Dr. Croll's Theory of Alternate Glacial and Warm Periods in each Hemisphere and of Inter-Glacial Climates," contending especially that the equatorial calms are not caused by the conflict between the north-east and south-east trade winds, "which never come into conflict," but mark the region where the air, being hottest and most charged with moisture, takes an upward motion. Secondly, he argued that the trade winds do not blow towards the earth's equator, but to the latitude of greatest mean heat, which does not coincide with the earth's equator and is never south of the equator, its mean being always 10 degrees north. This position is caused by the great preponderance of land over water in the northern hemisphere, as is shown by the isothermals. For these reasons, Mr. Howorth submitted that Dr. Croll's notion, that the position of the equatorial calms is due to the southern trade winds being stronger than the northern, is inadmissible. Inasmuch as the distribution of land and water was very much the same in the glacial age as now, it follows that the position of the heat equator must have been the same, and there is, therefore, no room for Dr. Croll's conclusion that the equatorial calms were south of the equator in glacial times, with the result of transferring the great body of warm water, which is moved by the trades, into the southern hemisphere, and thus cooling down the northern hemisphere until it became glaciated.

A discussion ensued, in which the President, Dr. Schuster, and Mr. C. N. Adams took part, and general agreement with these views was expressed.

Professor SCHUSTER, F.R.S., communicated a paper by Mr. Charles H. Lees, M.Sc., in which the method of some experiments undertaken for the purpose of finding a practical method for calculating the rate of loss of heat from a bar of a given shape, left to itself to cool in air, was described.

Mr. W. W. HALDANE GEE, B.Sc., exhibited and described two forms of apparatus which he had designed for determining the viscosity of liquids. The determination of viscosity, or fluid friction, is a matter of importance to the engineer in connection with the lubricating value of different oils. It has also become of great interest to the electrician since a connection has been discovered between electrical resistance and viscosity. The apparatus shown by Mr. Gee was specially designed with a view to further measurements. The literature of the subject seems to have largely escaped notice in this country. It is much more extensive than has been supposed, and Mr. Gee, therefore, presented a bibliography which he had compiled.

On the Law of Cooling, and its bearing on the Theory of the Motion of Heat in Bars. By Charles H. Lees, M.Sc., Berkeley Fellow of Owens College. Communicated by Arthur Schuster, Ph.D., F.R.S.

(*Received October 29th, 1889.*)

During the summer of last year I carried out at Strasburg some experiments on thermal conductivity which involved the "steady periodic" state of motion of heat in a bar, a method first used by Ångström. It consists in periodically heating and cooling one end of a bar, and after sufficient time has elapsed to make the temperature at any point of the bar a *periodic* function of the time only, determining by observation this function at several points of the bar. Observations at two points furnish in a very neat manner both the inner and outer * conductivity of the bar. Unfortunately, however, I found that the variation of temperature along the bar I used, could not be represented by the expression deduced by Ångström from Fourier's equation to the motion of heat in a bar. It was in the endeavour to find the cause of this discrepancy that the following work was undertaken on my return to Manchester.

Fourier's equation for the motion of heat in a bar is :—

$$c\rho\frac{\delta v}{\delta t}=k\frac{\delta^2 v}{\delta x^2}-\frac{p}{q}.hv. \qquad (1)$$

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*By inner conductivity is meant the conductivity of the material of the bar, and by outer conductivity the amount of heat lost from 1 sq. cm. of surface of the bar when that surface is at a temp. 1° C. higher than the surrounding gas. For details of the theory see Ångström, *Phil. Mag.* (4) 25, p. 130 (1863), or Tait, *Proc. R.S.E.* 8, p. 55 (1873).

Where v = excess of temp. at point x at time t over temp. of air which is supposed constant.

c = specific heat
ρ = density
k = inner conductivity
} of material of bar.

q = area of section.
p = perimeter of section.
h = outer conductivity.

It is deduced on the assumption that c, k, and h, are constant and that the isothermal surfaces are planes perpendicular to the axis of the bar.* If the restriction as to the constancy of c, k, h be removed, the equation takes the form—

$$c_v\rho\frac{\delta v}{\delta t}=\frac{\delta}{\delta x}\left(k_v\frac{\delta v}{\delta x}\right)-\frac{p}{q}.\,h_v.v. \qquad (2)$$

where the subscripts denote values of c, k, h, at temp. v. Now the experiments of Bède, Bryström, Naccari, and others shew that c_v seldom varies more than 10 per cent per 100° C., and the same holds for k_v according to the experiments of Forbes, Lorenz, Mitchell, &c. I find, however, that h_v often varies 50 to 100 per cent in the same interval. The first step towards a more correct theory seems then to be a determination of the variation of h_v.

A bar of diameter small in proportion to its length, if heated to a constant temperature and then suspended horizontally in air to cool, would during cooling be very nearly of the same temperature throughout. We have then $\frac{\delta v}{\delta x}=0$, and the equation of temperature is

$$-qc_v\rho\frac{\delta v}{\delta t}=\frac{p}{q}h_v v.$$

Or writing m for the mass, s for the surface of the bar, and $h_v v = hf(v)$ where h has same meaning as in the note (p. 57), we have

$$-mc_v\frac{\delta v}{\delta t}=shf(v). \qquad (3)$$

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*Théorie analytique de la Chaleur, art. 105.

The bars used to determine $f(v)$ were respectively of copper, iron, and zinc, 26 cms. long, 1·9 cm. diameter, and were nickel plated. They were heated to 100° C. in a hot air bath and then suspended by threads horizontally in air to cool. The temperature during cooling was determined thermo-electrically by means of iron-German-silver junctions soldered into small holes in each bar.

Assuming different forms for $f(v)$, taking c_v as being approximately a linear function of v, and integrating, we get different forms of v as a function of t. Out of these we can choose that one which, while simple, best expresses the facts observed. The forms $f(v) \equiv v$,* $v(1+bv)$,** v^n respectively were tried. The first two could not be made to correspond with the experiments, but the third for a suitable value of n, generally $=1{\cdot}21$, expressed them with a very close degree of approximation, over the whole of the range of temperature 30° to 100° C.

Writing in (3) $c_v = c(1+c'v)$, $f(v) \equiv v^n$ we have

$$-mc(1+c'v)\frac{\delta v}{\delta t} = shvn^n. \tag{4}$$

which on integration gives

$$v^{-\overline{n-1}}\left(1-\frac{n-1}{2-n}c'v\right) = \frac{sh}{mc}(n-1)t + \text{C}. \tag{5}$$

where C is an arbitrary constant.

To show the closeness of the approximation of this formula to the cooling, I give a series of values of $20\frac{sh}{mc}(n-1)$, deduced from observed values of v at different times during the cooling.

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* Newton's Law.

** Used by Kundt and Warburg, *Pogg. Ann.*, CLVI., to express the cooling of a thermometer in a sphere concentric with its bulb.

H. F. Weber, Mon. Ber. d. Berlin Akad. 1880, considers some correction of this form to be necessary in dealing with bars.

.0653	.0657	.0654	.0656	.0649	.0651
61	57	52	54	53	47
60	63	52	48	57	50
54	56	52	56	55	46
53	55	52	51	51	47

This is a case in which the agreement is about an average one.

The value of n found for the three bars used was 1·21 ; it was found to vary with the nature of the surface and the form of the section, but to be independent of the material of the bar. It seems probable that its value is determined by the nature of the surface of the bar, and by the form of the stream lines of the air flowing past it.

We can then write equation (2) with a very close degree of approximation, in the form

$$c_v\rho\frac{\delta v}{\delta t}\cdot=\frac{\delta}{\delta x}\left(k_v\frac{\delta v}{\delta x}\right)-\frac{p}{q}\cdot hv^n. \qquad (6)$$

This equation is evidently not satisfied by Ångström's value

$$v=\phi(x)+\sum_{n=1}^{\infty}A_n e^{-\mu_n x}\cos 2n\pi\left(t-\frac{x}{\lambda_n}+a_n\right).$$

which on account of the summation can only apply to a linear equation. The value of k_v can be best deduced by means of an experiment on the steady flow, *i.e.*, when $\frac{\delta v}{\delta t}=0$. We then have

$$\frac{\delta}{\delta x}\left(qk_v\frac{\delta v}{\delta x}\right)=phv^n.$$

which gives

$$\Big/ qk_v\frac{\delta v}{\delta x}\Big/_{x_1}^{x_2}=\int_{x_1}^{x_2} phv^n dx.$$

if there is no "source or sink" of heat between the limits x_1 and x_2.

Under the same conditions if $x_1 = \infty$, or is large enough to make $\frac{\delta v}{\delta x} = 0$ at the point x_1 we have

$$qk_v \frac{\delta v}{\delta x} = \int_{\infty}^{x} phv^n dx. \tag{7}$$

or

$$k_v = \int_{\infty}^{x} phv^n dx \Big/ q\frac{\delta v}{\delta x}.$$

The equation (7) is found to express fairly some recent observations of Mitchell,* who has determined the conductivity of iron by Forbes's method. The value of n for his 1¼″ square bar I find to be 1·26. The equation (7) would no doubt give k_v with great accuracy if, instead of the temperatures at different points of the bar in the "statical" experiment of Forbes being determined by thermometers sunk in holes in the bar, which thus break the continuity of the bar, they were determined by thermojunction, either fixed in the bar or movable as in the experiments of Wiedemann and Franz.

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* *Trans. Roy. Soc. Ed.*, July, 1887.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, November 4th, 1889.

Mr. J. COSMO MELVILL, M.A., F.L.S., President of the Section, in the Chair.

Mr. THOS. ROGERS exhibited the fruit of *Gunnera scabra*, now almost naturalized in Jersey, and Mr. CHARLES BAILEY described a peculiar gland found on the cotyledon of this plant.

Dr. ALEX. HODGKINSON described the rattle of the Rattlesnake, and shewed a specimen; and by connecting this with a battery demonstrated the noise the snake makes.

Mr. JAMES COSMO MELVILL exhibited a full series of the varieties and near allies of *Olivancillaria gibbosa* (*Born*), and remarked that this mollusc, perhaps better known by the name of *Oliva utriculus (Gmelin)* now superseded, is abundant in many parts of the Eastern hemisphere, its head-quarters being Tropical African, but impinging on Ceylonese and Mauritian coasts, and likewise extending as far as the Philippines (*Cuming*). It is perhaps one of the best known of all the family, but, in common with *O. Brasiliana*, *nebulosa*, *acuminata*, *hiatula*, and others, was relegated to new genera, *Agaronia* (*Gray*) and *Olivancillaria* (*Bolt*) owing to the possession of an operculum, which the typical forms of genus are without. In build also it is unusually massive, and the suture of the spire is more or less filled with a thick white callous deposit. Remarkably uniform in its general appearance and form, it possesses one well marked colour variety, probably from the sunny coral reefs of Mauritius, of a pale fawn yellow colour, the type being grey. This variety might be termed *O. gibbosa flavescens.* A specimen was also exhibited with the basal fasciole extended across the body of the shell, no other signs of malformation being evident, thus presenting a very beautiful effect. This had been obtained at the sale of the Dennison collection, in 1865, by Mr. Melvill, who had only seen one other similar instance since, in some public museum, no other shell in his experience ever having been subject to such a monstrosity. This specimen he had for years differentiated in his cabinet as var. monstr. *mediocincta.* The genera *Agaronia* (*Gray*) and *Olivancillaria* (*Bolten*) do not at present seem well defined. *Oliva nebulosa* and *acuminata*, both nearly allied to the shell under discussion, were classed by Tryon under *Agaronia* in company with *A. hiatula*, to which they are not closely allied. *O. nebulosa* especially comes so near to some forms of *O. gibbosa*, less inflated than usual, as to suggest a possible identity, but there are certain fine distinctions still to keep them separate. At all events the two shells should be placed in the same genus.

General Meeting, November 12, 1889.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., President, in the Chair.

Mr. W. J. WILLANS, of Manchester; Mr. H. E. HADLEY, Demonstrator in Physics, Owens College; and Mr. C. J. HALL, Doc. Mus. (Lond.), of Southport, were elected ordinary members.

Ordinary Meeting, November 12, 1889.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

Dr. HODGKINSON mentioned a case that had come under his notice in hospital practice, which suggested a possible cause of error in taking the temperature of patients. It was found that a girl, who was not suffering from any febrile complaint, registered abnormally high temperatures. Observation led to the discovery that she was in the habit of wrapping the thermometer in the edge of the blanket and then inserting it in her mouth during the temporary absence of the medical man. She thus obtained a dangerously high register, which resulted in her being supplied with food more to her taste than that which she would otherwise have received. Dr. Hodgkinson illustrated the phenomenon by wrapping a thermometer in a handkerchief, placing it in his mouth, and blowing through the handkerchief, the thermometer running up to 102 degrees in a few seconds. A discussion on the causes of the phenomenon followed, in which Mr. W. H. Johnson, Dr. Bottomley, Professor W. C. Williamson, Mr. Nicholson, Mr. Gwyther, Mr. Faraday, and the President took part, the conclusion being that the increase of temperature was the result of the work done by the capillary attraction of the moisture.

Additional portions of a paper by Mr. H. H. HOWORTH, M.P., on "Dr. Croll's Theory of Alternate Glacial and Warm Periods in each Hemisphere and of Inter-glacial Climates" was read. In the course of the paper attention was called to the fact that in a paper read before the Society in 1851, and published in the *Memoirs*, Alderman Thomas Hopkins anticipated Dr. Croll's argument that the great ocean currents are the result of the pressure and traction of winds. A discussion on Dr. Croll's theory of alternating glacial and warm periods ensued.

A Criticism of Dr. Croll's Theory of Alternate Glacial and Warm Periods in each Hemisphere, and of Interglacial Climates. By Henry H. Howorth, M.P., F.S.A.

(*Received December 31st, 1889.*)

I propose in the following pages to criticise a theory which dominates a large number of scientific men and is the foster-mother of much additional speculation, I mean Dr. Croll's famous explanation of geological changes of climate which he elaborated in a series of papers in the *Philosophical Magazine*, and afterwards stated more fully in his well-known works "Climate and Time and "Climate and Cosmology." Not only is this theory widely held, but it would be difficult to find one supported by greater skill and ingenuity, nor are there many works better worth reading and more inspiring than the two just named. I wish to say this the more emphatically because I cannot accept their conclusions.

There is nothing hesitating or apologetic about Dr. Croll's attitude. "I have studiously avoided," he says, "introducing anything of a hypothetical character. All the conclusions are based either on known facts, or admitted physical principles. In short, the aim of the work is to prove that similar changes of climate follow, as a necessary effect, from admitted physical agencies, and that these changes, in as far as the past climatic condition of the globe is concerned, fully meet the demand of the geologist." (Preface V. and VI.)

It is not quite easy to concentrate the essential elements of Dr. Croll's argument since his work contains several long parenthetical chapters discussing side issues. I will try to state his case as much as possible in his own words before I proceed to criticize it.

After expressing his agreement with those astronomers who cannot connect a glacial period with any change in the relations of the earth and sun, Dr. Croll goes on to say :— "The important fact, however, was overlooked that although the glacial epoch would not result *directly* from an increase of eccentricity, it might nevertheless do so *indirectly*. Although an increase of eccentricity could have no direct tendency to lower the temperature and cover our country with ice, yet it might bring into operation physical agents which would produce this effect." He then goes on to say that such a change in the eccentricity "would bring into operation a host of physical agencies, the combined effect of which would be to lower to a great extent the temperature of the hemisphere whose winters occur in aphelion, and to raise to nearly as great an extent the temperature of the opposite hemisphere, whose winters occur of course in perihelion." "By far the most important of all these physical agencies, and the one which mainly brought about the Glacial epoch," he continues, "is *the Deflection* of ocean currents."—*Climate and Time*, 15.

In his essays on Climate and Cosmology, he formulates more in detail what he conceives to be the ultimate result of these agencies. "When," he says, "the eccentricity of the earth's orbit is at a high value, and the northern winter solstice is in perihelion, agencies are brought into operation which make the south-east trade winds stronger than the north-east, and compel them to blow over upon the northern hemisphere as far probably as the tropic of Cancer. The result is that all the great equatorial currents of the ocean are impelled into the northern hemisphere, which thus, in consequence of the immense accumulation of warm water, has its temperature raised, and snow and ice to a great extent must then disappear from the arctic regions. When the precession of the equinoxes brings round the winter solstice to aphelion the condition of things in the two hemispheres is reversed, and the north-east trades then blow over upon the southern hemisphere, carrying the great equatorial currents along with them. The warm water being thus wholly withdrawn from the northern hemisphere its temperature sinks enormously, and snow and ice begin to accumulate in temperate regions. The amount of precipitation in the form of snow in temperate regions is at the same time enormously increased by the excess of the evaporation in low latitudes resulting from the nearness of the sun in perihelion during summer." (*Climate and Cosmology*, 15 and 16.)

This is shortly the glacial theory as taught by Dr. Croll, and it involves the conclusion that there has been throughout geological time an alternate glaciation of each hemisphere, ultimately caused by changes in the eccentricity of the earth's orbit, and directly engendered by the greater amount of warm water forced into each hemisphere by the alternately greater potency of the Trade winds North and South of the Equator. This being the theory, let us now examine it with the care which its wide acceptance demands.

I may at once say, that at least two of Dr. Croll's most important postulates seem incontrovertible.

His prime postulate is that the chief factor in determining the distribution of heat over the world is the direction of ocean currents. This he emphasizes in many ways. *Inter alia*, he says, "It will be seen that to such an extent is the temperature of the equatorial regions lowered, and that of high temperate and polar regions raised, by means of ocean currents, that were they to cease, and each latitude to depend solely on the heat received directly from the sun, only a very small portion of the globe would be habitable by the present race of beings. This being the case, it becomes obvious to what an extent the deflection of ocean currents must affect temperature." (*Climate and Time*, 15). With this general postulate I have no quarrel. It seems to me to be sound, and to be supported by abundant evidence. So it seems to me is the following more concrete corollary which he draws from it.

Applying himself especially to the Gulf Stream, he calculates that the quantity of water it conveys is probably equal to that of a stream fifty miles broad and 1,000 feet deep, flowing at the rate of four miles an hour, and that its mean temperature on leaving the Gulf of Mexico is not less than 65°. This is one-half only of the volume of the stream as calculated by Maury, Herschell, and others. Taking its speed at only two miles an hour, and the average temperature of the return stream at 40°, showing a loss of 25° of heat, Dr. Croll argues that the quantity of heat which is transferred daily by the Gulf Stream is 77,479,650,000,000,000,000 foot-pounds, and that the quantity conveyed by it in one year is equal to the heat which falls on an average on 3,436,900 square miles of the arctic regions. As the frigid zone or arctic regions contain 8,130,000 square miles, there is therefore nearly one half as much heat transferred from tropical regions by the Gulf Stream as is received from the sun by the entire arctic regions, the proportion being nearly as 2 to 5 (*id.*, 24–27), and this without taking into calculation the greater amount of heat absorbed by the air in the Arctic regions in consequence of the obliquity of the sun's rays, which in the article "Climate" in the E. B. is calculated to be 75 per cent. Comparing the quantity of heat conveyed by the Gulf Stream with that conveyed by aerial currents, he argues that it would require a current of air 31,234 times the volume of the Gulf Stream at the same temperature to convey the same heat, and he concludes that the quantity of heat conveyed by the Gulf Stream alone from the tropical to the temperate and arctic regions is probably greater than by all the aerial currents which flow from the equator. And he argues with force that since the winds flowing from the equator are the upper anti-trade winds, which come from an altitude above the snow line, and therefore below 32° in temperature, through which they have to blow for some days, they cannot bring much, if any, heat from thence (*id.*, 27 and 28). It is generally admitted that the Gulf Stream causes the mean annual temperature of our island to be 12° above the normal temperature due to the latitude, but Dr. Croll shows that this underrates the total effect of the Gulf Stream in these latitudes, since the mean referred to is itself raised by other tropical currents in the Pacific. He also shows that the very great flexure of the isothermic lines in the North-east Atlantic can be due to nothing else but the Gulf Stream, and he adds :—" On no point of the earth's surface does the mean annual temperature rise so high above the normal as in the Northern Atlantic, just at the arctic circle, at a spot believed to be in the middle of the Gulf Stream. This place is no less than 22°5 above the normal, while in the North Pacific the temperature nowhere rises more than 9° above the normal" (*id.*, 46).

With this reasoning I have no quarrel whatever, and if such be the effects of the Gulf Stream we may well ask with Dr. Croll, how enormous must be the quantity of heat conveyed from the equatorial regions by all the ocean currents together!

Professor J. D. Forbes, putting aside the effect of currents, calculated what would be the temperature of the equator and poles were the earth all water or all land. His result was that if it were all water 71°·7 would be the temperature of the equator and 12°·5 the temperature of the poles, and were the surface all land 109°·8 would be the temperature of the equator, and 25°·6 that of the poles. It is therefore perfectly certain, argues Dr. Croll, that had he added to his result the effect due to ocean currents, and had he been aware that about one-fifth of all the heat possessed by the Atlantic is actually derived from the equator by means of the Gulf Stream, he would have assigned a temperature to the equator and the poles, showing much greater divergence. Ocean currents convey heat to high latitudes, and aerial currents distribute it over the land. "Exclude," says Dr. Croll, "the waters of the Pacific and Atlantic from temperate and polar regions, and place them at the equator, and nothing now existing on the Globe could live in high latitudes" (*id.* 51). I have given a *résumé* of Dr. Croll's arguments on this question, not only because I believe them to be substantially sound and incontrovertible, but because his conclusions on this issue will be of service at a later stage of my argument. The postulate then that the climate of the earth is largely the result of the distribution of ocean currents seems to me reasonable. This in effect means that the climate is largely due to the effect of the great equatorial current, which is the main liquid reservoir of heat, and of which the Gulf Stream in the Atlantic, the Kuro Siwo in the Pacific, etc., etc., are mere prolongations and branches. So far I raise no issues with Dr. Croll.

The next postulate of Dr. Croll is that the ocean currents are due to the blowing of the winds. Here again I believe him to be substantially right, but as his results on this head are still disputed by a considerable school of physicists, especially abroad. I think it well to state his arguments in some detail.

The real cause of ocean currents exercised physical writers from early days. The great majority of them at first, including Maltebrun and Humboldt, attributed them in the main to the rotation of the earth, which was supposed in some way to leave behind its loose envelope of water and air as it moved along. But rotation, as Mr. Croll says, exercises no influence in generating motion in any body placed on the earth's surface. If this body, however, be already in motion, no matter in what direction the motion may be, rotation will deflect it to the right in the northern hemisphere and to the left in the southern hemisphere, as has been shown by Mr. Ferrel (*Nature*, V., 201.)

Putting aside the earth's rotation as an impossible cause of ocean currents, we will now turn to the theory advocated in different ways by Maury and Carpenter, that they are due to gravitation. Maury urges that "all the currents of the ocean owe their origin to the difference of specific gravity between sea water at one place and sea water at another; for wherever there is such a difference, whether it is owing to a difference of temperature or a difference of saltness, etc., it is a difference that disturbs equilibrium and causes currents."

Dr. Croll has no difficulty in putting Maury upon the horns of a dilemma in regard to this double cause of density, for while he urges in one place that the great ocean currents are due to the high temperature of the equatorial regions which make their waters *less dense* than those of the poles, he urges in another that these same currents arise because the equatorial waters, in consequence of their greater saltness, are *more dense* than the waters of the polar regions; and Croll says, with justice, that these two causes neutralise each other, and cannot be combined to produce a common result. Not only so, but according to Maury himself, the ocean, as far as 40° N. and S. of the equator, does not differ in density; that is to say, it does not differ in density where the greatest of ocean currents takes it rise.

But Dr. Croll is not content with creating this dilemma. According to a very simple law of hydrostatics, if a sheet of water is of uniform temperature and composition, and therefore of uniform specific gravity, its surface will be a perfectly horizontal plane. If the composition remains the same, but one portion of it is warmer than another it will require a greater depth of water to make a column of it of the same specific gravity when it is hot than when it is cold ; and as the statical equilibrium of liquids is dependent on there being equal pressures on equal areas, the surface, instead of being a flat plane, will form a slope from the lightest, and therefore highest part of the water to the densest or lowest. Thus, if the water is warmer at the equator than at the pole, the water must stand higher in the former district than the latter, and there must be a slope from one to the other.

Such a slope, while securing statical equilibrium to the mass must cause a molecular disturbance, since the particles of water on it will begin to roll down, until a perfect level is secured ; and it is clear, as Dr. Croll urges, that we can never secure both conditions of equilibrium at the same time so long as a difference in temperature exists between the two areas (*Climate and Time*, *op. cit.*, 178); but this molecular movement of the surface particles of the water to restore a dead level continually could not clearly create a circulation of the ocean. Nor could a circulation of the water be produced so long as the whole mass was in statical equilibrium, and when there would consequently be no tendency to circulate at all. This equilibrium must be disturbed in some way, and this can only be by the denser column of water, namely, that at the poles being kept at a higher or a lower level than it would be if in equilibrium. Such a column would then do more or do less than balance a similar column of the water at the equator and statical equilibrium would thus be disturbed.

But this involves an appeal to some other factor than a difference of specific gravity which could not permanently keep up an inequality of balance between a column of water at the pole and one at the equator. Maury, however, makes no such appeal. His argument is therefore suicidal.

Dr. Carpenter, unlike Maury, does not postulate a slope between the equator and the poles down which the water flows. He denies its existence and its necessity.

According to him, the cold in the Arctic regions contracts the water, increases its specific gravity, and lowers *its level* as compared with the water in the equatorial region. To make this good a surface flow sets in towards the former. But in restoring *the level* the additional water disturbs the equilibrium of pressure, and the column of polar water becomes heavier than that of the equatorial water, "whereby," to use his own words, "a portion of its heavy bottom water is displaced laterally, causing a further reduction of level, which draws in a further supply of the warmer and lighter water flowing towards its surface, so that the entire column of polar water may be said to be in a state of constant descent, like that which exists in the water of a tall jar when an opening is made at the bottom, and the water which flows away through it is replaced by an equivalent supply poured into the top of the jar."

In the first place, Dr. Carpenter ignores the difference of density caused by saltness, which compensates very largely, if not entirely, for that created by heat, and makes it far from improbable that there is no difference in specific gravity between water from the equator and the poles, a view in which Professor Wyville Thomson concurs (*Climate and Time*, 129.) Let this pass, however, and let us turn to the problem as he puts it, and try and measure the amount of pressure, and, consequently, of movement, which can be got out of Dr. Carpenter's *primum mobile*, the arctic cold. He seems to argue as if the pressure at the base of the polar sea, which, according to his theory, squeezes out its lowest layers, and causes the water to begin to circulate, is to be measured by the whole height of the polar column of water. This is by no means the case. So long as the ocean is in equilibrium the column of polar water exactly balances the column of equatorial water, and all the pressure it can exercise is exhausted in balancing the column of water at the equator. When the equilibrium is disturbed, the amount of disturbance is to be measured not by the weight of the whole polar column, but by the difference between the pressure of the polar and equatorial columns, and no more. It is, as Dr. Croll says, as if two scales of a balance each hold a ton weight, and are equally balanced, and a pound is added to one of them. The scale to which the addition is made sinks down, not with the pressure of a ton, but of a pound only.

When we measure, therefore, the result of Dr. Carpenter's hypothesis we shall find that the amount of pressure and consequent displacement is the weight of the water which has been added to the polar column to restore its equilibrium with the equatorial one ; and this is clearly to be measured by no other standard than the difference in density, if any, resulting from difference of temperature between the water at the equator and the pole.

It is this difference in density which we have seen reason to question the existence of, which would, if anything, cause the polar column to sink, and a corresponding amount of water to flow over it.

Ignoring the important element of saltness, as Dr. Carpenter does, and accepting the conditions as he presents them, it is not difficult to measure this and thus to see whether the force generated would be sufficient to create an ocean current. Sir John Herschell long ago showed that the force would be a very slight one. Dr. Croll's more recent calculation is that in order to create statical equilibrium the water at the equator must be about 4 feet 6 inches higher than that at the poles. This then is the amount of inequality of level created by the action of the sun upon the water of the ocean. Inasmuch as, according to Dr. Carpenter, the first movement is caused by the column of water at the pole being not equal to, but heavier than, and therefore overbalancing that at the equator, we must reduce this amount considerably, for it is obvious that we can only add weight to the polar column by increasing its height, and therefore reducing the difference between it and the column at the equator. "Suppose then," says Dr. Croll, "that the weight of the polar column exceeds that of the equatorial column by 2 feet of water, the difference of level between the two columns would then amount to only 2 feet 6 inches. This would give a force of $\frac{1}{13200000}$ that of gravity, a force which does not much exceed a grain on a ton of water." This would be the measure of the force tending to push the water at the pole towards the equator. But, as the experiments of Dubuat have shown, water will not flow on a slope of 1 in 1,000,000, that is to say, when the force of gravity acting on it is thirteen times greater than in the case just cited. This seems clearly to show that the cause appealed to by Dr. Carpenter is quite inadequate to explain the origin of ocean currents.

Dr. Croll has several minor polemics with his opponent and his supporters, but this complete answer is sufficient, and it seems to me to put out of court all theories of ocean circulation depending on gravity for their explanation.

After criticizing the theories which attribute the flow of ocean currents to the rotation of the earth and to gravity, and, in my view, showing them to be impossible, Dr. Croll goes on to argue that the great ocean currents are the result of the pressure and traction of winds, a view in which he was forestalled in a valuable paper published as far back as 1851, by Alderman Thomas Hopkins, in the *Memoirs* of this Society, which he would no doubt have quoted if he had known of it, for he is a model of fairness as well as lucidity. Dr. Croll has elaborated many arguments to show that winds are competent to create ocean currents, and that the observed facts can be explained, and explained most satisfactorily, by their agency, and there can be small doubt that here again he is substantially right. But while conceding that the winds are the main cause of ocean currents

I cannot go so far as to deny the existence of at least one minor and effective cause.

The great tropical current, which for our present purpose is the most important, seems to have at least one other impulse to which Dr. Croll has not given due weight. As Reclus puts the case, "Every difference of level which is produced on the liquid surface in consequence of prolonged winds, *heavy rains, or very active evaporation*, causes as a necessary result, the formation of a current, for the water, whether salt or fresh, ever seeks its level, and incessantly flows from the more elevated places towards the depressions. . . . . The equatorial basin incessantly heated by the solar rays, loses a great quantity of water which is transformed into vapour, and rises into the higher strata of the atmosphere, to be condensed into clouds. Admitting that the annual evaporation is about 14 feet, which is probably below the reality, the quantity of fluid raised from the Atlantic in the tropical zone would be nearly 120 billions of cubic yards, and would consequently represent the same value as a cubic mass of water nearly 30 miles in extent. It is true that a considerable part of this vapour, the half perhaps, falls as rain into the seas, situated beyond the tropics, and over the neighbouring continents. Near the equator, therefore, much more water is drawn from the ocean by evaporation, than is restored to it by the clouds, and, in consequence, an immense void is formed which can only be filled by the waters from the polar basins, where the contributions of snow, rain, and ice exceed the loss in vapour. This superabundant mass of fluid continually flows towards the basin of the torrid zone, and forms the two great currents which meet one another from the opposite poles in the Atlantic and the Pacific, incessantly describing a regular orbit like the celestial bodies. But, the excess of evaporation which occurs in tropical waters is not the only reason of this great movement of the polar seas towards the torrid zone. The trade winds, attracted by the force of equatorial heat, blow incessantly in the same direction, and always driving the waves before them, thus accelerate the march of the oceanic current." (Reclus, *The Ocean*, 60 and 61.)

With this argument, except the part which brings the intrusive water from the poles, I very largely agree, and it seems to me that, if there were no winds at all, but evaporation were to go on as it does now, it would inevitably cause a certain circulation of water between the torrid and the colder zones, and I cannot, therefore, attribute all this movement to the wind as Dr. Croll seems disposed to do. This, however, is a minor issue, and it seems clear that the winds are, as Dr. Croll makes them, the really efficient factors in creating ocean currents.

So far I have no dispute with Dr. Croll. I would remark that the discussion of these postulates, about which I raise no question, forms a substantial part of *Climate and Time*, occupying at least 130 pages of it, and that his clear and incisive criticism of Maury, Carpenter, and others, produces an impression in casually reading the book that, in destroying their arguments, he is establishing his main position, which is not so, these polemics being really side issues, and filling only a subsidiary part in the main argument.

Having granted two of Dr. Croll's postulates, namely that climate is largely dependent on the distribution of ocean currents, and that these are chiefly dependent on the winds, let us now come to closer quarters and see whether the demands he makes upon the aerial currents are justifiable.

Meteorology is a difficult inquiry, and full of pitfalls. If we are to tread its quagmires with any confidence we must do so in very elementary fashion. "If," says Mr. Buchan, "atmospheric pressure were equal in all parts of the earth, we should have the physical conditions of a stagnant atmosphere. Such, however, is not the case.

Let there be produced a concentration of aqueous vapour over a particular region, or let one region show a higher temperature than what prevails around it, then from the different densities and different pressures thereby produced the equilibrium of the atmosphere is destroyed, and, as might be expected from the laws of aerial fluids, movements of the air or winds set in to restore the equilibrium." (E.B., XVI., 143). This is incontestible. So is the following: "All winds may be regarded as carried directly by differences of atmospheric pressure, just as the flow of rivers is caused by differences of level, the motion of the air and the motion of the water being both referable to gravitation. The wind blows from a region of higher towards a region of lower pressure—in other words, from where there is a surplus to where there is a deficiency of air" (*id.*). The next argument is equally sound. "So far as is known, differences of atmospheric pressure, and consequently all winds, originate in changes occurring either in the temperature or the humidity of the air over restricted regions. Thus, if two regions contiguous to each other come to be of unequal temperature, the air of the warmer region, being specifically lighter, will ascend, and the heavier air of the colder regions will flow in below to take its place. Of this class of winds the sea and land breezes are the best examples. Again, if the air of one region comes to be more highly charged with aqueous vapour than the air of surrounding regions, the air of the more humid region, being lighter, will ascend, while the heavier air of the drier regions will flow in below, and take its place. Some part of the vapour will be condensed into cloud or rain as it ascends, heat will be thereby disengaged, and the equilibrium still further disturbed" (*id.*).

The paragraphs I have quoted state clearly some of the elementary postulates of general pneumatics. Let us now apply them to the earth. As is familiar to everybody, the sun's rays exercise their most potent influence in the neighbourhood of the equator, which may be looked upon as a terrestrial furnace, and their least, at the two poles, which may be considered as two refrigerators.

It follows that about the equator the air is not only being heated and expanded, but since heat is the great evaporator it is also being charged with moisture more rapidly than it is elsewhere, and that if the earth were homogeneous, and entirely covered with water, there would be a progressive lightening of the air going on from its densest and least humid portions at the poles to its most expanded, and most humid at the equator. That is to say, there would be a continuously diminishing atmospheric pressure as we neared the equator from the poles. The result would be that a column of damp and expanded, and therefore light air would rise up continuously round the equator. In order to restore equilibrium, the void thus created would be filled by an indraft from the colder regions on either side, the ascending column would presently spread out in both directions, north and south, and thus a circulation would begin causing near the ground a more or less north wind in the northern hemisphere, and a south wind in the southern to blow towards the equatorial region, while above these two winds would be two other currents flowing in the opposite direction. If the earth were a cylinder and not a sphere, and there were no cold of space to invite radiation and cool the currents of air as they rise from the ground, and if its surface were homogeneous, and covered all over either with water or dry land, there would probably be a perfect and continuous circulation of winds between the equator and the poles—the postulated foci of least and greatest barometrical pressure. The three factors just named, however, introduce a very different condition of things, and limit the area over which these winds can blow very materially.

In the first place let us turn to the shape of the earth.

Inasmuch as the earth is a sphere, with its furnace round the equator and its refrigerator at each pole, each hemisphere becomes covered with a funnel of air, with its terminus at the pole *closed*, and thus it comes about that the polar area cannot find room for all the air which is heated at the equator. Professor Tyndall puts the case clearly :—"On this terrestrial globe," he says, "I trace with my hand two meridians. At the equator of the globe they are a foot apart, which would correspond to about 1,000 miles on the earth's surface. But these meridians, as they proceed northwards, gradually approach each other, and meet at the north pole. It is manifest that the air which rises between these meridians, in the equatorial regions, must, if it went direct to the pole, squeeze itself into an ever-narrowing bed, and the space around the poles is unable to embrace the air from the equator." (*Heat as a Mode of Motion*, p. 168–9.) This is a most important fact, which has been overlooked in some speculations on meteorology, and it interferes completely with those theories which look so symmetrical, and which postulate an exchange of air between the equator and the poles, an exchange which cannot physically take place on a considerable scale on a spherical body like the earth. Another interference is caused by the cold of space, which has the effect of cooling the upper air which has risen in the equatorial region, and thus making it denser after it has travelled some distance, until it becomes heavier than the subjacent air, and must sink by the force of gravity long before it reaches the two poles. The presence of great continental areas separating the great oceans, where heat is more quickly absorbed and more quickly radiated than over water, must also interfere somewhat with the continuity of the circulation. We may, however, neglect this at present, and consider what must be the result of the operation of the other two causes. There can be little or no doubt that the result must be to greatly shorten the journey of the equatorial air in its circuit, and to greatly lessen the course of the winds, which flow towards the equator, and this is exactly what we find to be the case. The trade winds do not blow from the polar or even from the temperate zones, but they blow from latitudes even nearer the equator, their limits being bounded towards the north and south by the so-called calms of Cancer and Capricorn respectively.

As we have seen, the column of equatorial air, on reaching a certain height, spreads out and begins to flow to the north-east and south-east, as the anti-trade winds. As Mr. Scott says, this overflow takes place at a great height, for the level of the counter current has never been reached by the ascent of any of the peaks in the equatorial Andes; but that the air does flow away in the upper strata is abundantly proved by the fact that clouds are often noticed moving in a direction contrary to that of the trade wind below. A proof even more striking is afforded by the fall of ashes from the volcanoes in Central America in the Spanish Main, and from those in the Dutch East Indies in the Western Pacific. An instance of he former occurrence was recorded in January, 1835, when ashes from Coseguina, on the Bay of Fonseca, were borne in four days to Kingston in Jamaica, in the teeth of the trade wind. The latter phenomenon took place in 1815, when the ashes from Tomboro, in Sumbawa, were carried to Amboyna, a distance of 800 miles, athwart the direction of the south-east trade.

"When we reach the outer edge of the trade wind zone we find the counter current gradually descending to the sea level. On the Peak of Teneriffe (lat. 28° N.), and on Mauna Loa, in the Sandwich Islands (lat. 20° N.), there are constant south-west winds at the summit. . . . When these upper currents reach the earth, about the latitude of the tropics of Cancer and Capricorn, a great portion of the air which goes to form them is caught in the under current and drawn back to the equator; but the remainder flows on;

and outside the parallels named in both hemispheres we can no longer trace the persistence of upper and lower currents at all seasons, but the predominant direction of the air motion is from the equator towards the pole; and this appears to increase in steadiness and force with the height above the ground." (*Elementary Meteorology*, by R. H. Scott, 244-246.)

This clearly proves that the circulation of the trades and anti-trades is limited to the region between the equatorial calms on the one hand, and the calms about the two tropics of Cancer and Capricorn respectively. This we should in fact expect from an examination of the tables of barometric pressure. The mean pressure in the equatorial belt is only about 29·84 inches, while between the 30th and 35th parallels it reaches its maximum of 30 to 30·08 inches; and as we have seen, and as has been clearly proved, the lower winds blow from situations of high pressure to those of low pressure, while the return upper currents go the reverse way.

It is most important in the discussion we are engaged in to remember this limitation in area of the trade winds, for it is the trade winds alone with which we have virtually to deal, since they give the equatorial current its principal impulse.

With the winds north and south of the two tropics we have nothing to do in this discussion. They are much less constant than the trades, their course being subject to many influences, but in the main it is probable that there is a general circulation between the temperate and the arctic regions. This circulation, however, belongs to an entirely different system, and does not, so far as we can see, interfere with the trades and the anti-trades, which form a circuit of their own. Dr. Croll has largely ignored this fact. He argues as if the strength of the respective trade winds is dependent on the fact that the difference in temperature between the equator and the north pole is not the same, but greater than the difference between the respective temperatures of the equator and the south pole. *Inter alia*, he says: "As the existence of the winds depends mainly on the difference of temperature *between equatorial and polar regions*, any cause which will greatly affect this difference of temperature will likewise greatly affect the winds." He argues that an increase or decrease in the difference of temperature between equatorial and polar regions would produce an increase or decrease in the strength of the winds, and consequently in the strength of the currents, and that a *difference in the difference of* temperature between the equator and the two poles would affect the distribution of aerial and consequently of ocean currents, and would in turn produce a corresponding increase in the difference of temperature between the two hemispheres. This change, again, would tend to strengthen one trade wind and to weaken the other," etc., etc.

I cannot agree with this conclusion, which is at issue both with *a priori* and with empirical tests.

The chief condenser and refrigerator, where the warm damp air of the torrid zone is deprived of its heat and moisture, is not the area at each pole but the upper region of the atmosphere.

As we have shewn elsewhere, the warm current which rises at the equator, rises at least higher than the peaks of the Andes, that is far above the snow-line, and into a region which but for this current would be perpetually below 32° in temperature, and it remains in the cold region during the greater part of its journey to the two tropics.

It does not matter, therefore, how cold the poles are made, they cannot drag or pull this equatorial current of air towards them. It has much closer at hand, namely, in the regions of space, a much colder refrigerator than either pole, which must inevitably cool it down and deprive it of moisture, and therefore force it to descend and come to the ground long before it can reach the poles.

The polar cold, therefore, cannot affect the circulation of the trade winds. The hotter the equator, the hotter and more charged with vapour will the air be that rises there. That is true, but this will only make it more buoyant and rise higher to a colder stratum, and thus the greater heat of the furnace will be compensated by the greater cold of the stratum to which the air will rise, that is of the refrigerator. It is well known that the equatorial current discharges its great mass of moisture in the shape of very heavy rain—(that is to say, has its moisture condensed) before it reaches the two tropics.

This makes it clear that the trade winds belong to a circulation of air outside of polar influence altogether, and are not affected, as Dr. Croll argues, by a greater or less temperature at the poles.

Let us now advance another step, limiting ourselves strictly to the trade winds. If the earth were still, the trades would move directly towards the parallel of greatest heat, while the anti-trades would move directly away from it, and their motion would be at right angles to the equator. This direction, however, is interfered with by the rotation of the earth, for although this rotation will not induce a movement in anything placed upon the earth, it will, as we have seen, deflect the direction of anything already in motion.

"In virtue of the rotation of the earth," says Mr. Buchan, "objects on its surface at the equator are carried round towards the east at the rate of about 17 miles a minute on receding from the equator. This rate of velocity is being continually diminished, so that at 60° N. L. it is only about 8½ miles a minute, and at the poles nothing. From this it follows that a wind blowing along the earth's surface, in the direction of the equator, is constantly arriving at places which have a greater eastward velocity than itself. As the wind thus lags behind, these places come up, as it were, against it, the result being an east wind. Since, therefore, the wind north of the equator is under the influence of two forces—one, the low pressure near the equator, drawing it southwards, and the other, the rotation of the earth, deflecting it eastwards—it will by the law of the composition of forces take an intermediate direction, and blow from north-east. For the same reason, south of the equator the south is deflected into a south-east wind" (E. B. XVI., 103.)

While the rotation of the earth gives the two trade winds a certain westerly motion, it for the same reason gives the anti-trades an easterly movement, since in this case the winds are moving from a latitude where the earth has a great, to one where it has a small rotatory movement. That this is so we can tell by the direction taken by the volcanic ashes carried by the anti-trades to which we have already referred. The result, then, is that the trades and anti-trades, instead of blowing directly to and from the equator, blow at a certain angle to it.

Between the north-east and south-east trades is the well known belt of equatorial calms. These calms Dr. Croll, following other writers, attributes to the conflict of the two sets of winds, which, according to him, create a neutral belt between them. To this view I cannot at all assent.

If the effect of heat and the addition of moisture, upon air were to leave its density and specific gravity unaltered, and merely to induce it to move laterally, and thus form a wind, the argument might hold good, but the immediate effect of adding heat and moisture to air is to make it lighter, and also to expand it, and it must begin to move in the direction of least resistance, that is to ascend. As the cold air from the pole gradually moves towards the equator, it gets more and more heated, and more and more full of moisture, and more and more expanded and buoyant. On the contrary, that which proceeds from the equator towards the poles gets more and more contracted and heavier. The former current, therefore acquires, in addition to its horizontal movement, first a *tendency* to rise, and then an actually upward movement, and the latter a corresponding *tendency* to sink, and eventually a downward movement ; and when the focus of heat or cold is reached this upward and downward movement respectively becomes dominant, and the currents of air do not press against each other, but rise up almost vertically and lose their lateral motion. It does not seem to me that there can be any pressing of one set of winds against the other, and both the north and south trades, on reaching their furnace, must move upwards, and not laterally. The region of calms merely marks the place where the vertical movement upwards and downwards takes place.

It is clear that the winds could not under any circumstances meet each other face to face, since, as we have seen, the motion of the earth gives them a very decided motion from east to west. If they collided at all, therefore, instead of neutralizing each other, they would acquire a more direct course westwards, as the corresponding currents of water do ; and instead of a region of calms in the tropics we should have a region of more or less violent east winds along that zone, of which I know of no adequate evidence. In every way the question is examined, it seems to me to be impossible to attribute the equatorial calms to the neutralizing tendency of a conflict of winds, as Dr. Croll urges, and this is a most important factor in his argument.

Let us proceed, however ; it is perfectly true, and an elementary fact in physical geography, that the two trade winds do not always blow between the same parallels, and that the region of intervening equatorial calms is not stationary, but that the whole move together, to and fro, north and south, as the sun moves from one equinox to the other. This movement, Dr. Croll seems to argue, is due to the greater strength of the north trade at one time of the year than at another, enabling it to force back the other trade wind and the calms several degrees. As we have seen, there is no evidence of any pushing at all, and such a postulate is contrary to all we know.

The movement of the trades calms to and fro is in fact due to another and a very simple cause. The fact is that circulation of the two great constant winds has nothing to do with the earth's *equator of form* at all. Their circulation is induced by the heating effect of the sun, and it is to where the furnace burns the hottest, that is to say, to the latitude of greatest mean heat that these winds, by the laws of pneumatics, must tend. Now the latitude of greatest mean heat does not coincide with the equator, and wherever it happens to be, *there* must be the focus of the calms, and there the medial line between the trades. It is the situation of the furnace of greatest heat for the time being and not the relative strength of the trades that fixes the situation of the combined belt of trade winds and equatorial calms. This is not mere conjecture, but it agrees with observed facts as well as with theory, and this must be true whatever eccentricity we may postulate for the earth's orbit.

I cannot, therefore, at all agree with Dr. Croll's remarks on the subject when he says :—" It has been shown that an increase in the eccentricity of the earth's orbit tends to lower the temperature of the one hemisphere, and to raise the temperature of the other. The consequence of this is that the aerial currents of the hemisphere, in which the difference of temperature between the equatorial and the temperate and polar regions is greater, is stronger than those of the other." " This," he adds, " would be more especially so with the trade winds. The stronger trades would blow across the equator and drive the median line between them, and the opposite trades into the other hemisphere. If the north-east trades, for instance, were the stronger, the equatorial waters would be impelled more to the southern than to the northern hemisphere; and the warm water carried over in this manner to the southern hemisphere would tend to increase the difference of temperature between the two hemispheres. This change, again, would in turn tend to increase the difference of temperature between the two hemispheres. This change, again, would in turn tend to strengthen the north-east and to weaken the south-east trades, and would thus induce a still greater flow of equatorial waters into the southern hemisphere, a result which would still more increase the difference in temperature between the northern and southern hemisphere, and so on—the one cause reacting on the other, so as to increase its effects." (*Climate and Time*, 227-229.) Having stated this principle in general terms, Dr. Croll proceeds to test it by a critical example, and says:—" We have in the present state of things a striking example of the extent to which the median lines between the two trades may be shifted, and the position of the great equatorial currents of the ocean may be affected by a slight difference in the relative strength of the two aerial currents. The south-east trades are at present a little stronger than the north-east, and the consequence is that they blow across the equator into the northern hemisphere to a distance sometimes of 10 or 15° ; so that the mean position of the median line lies at least six or seven degrees north of the equator. And it is doubtless owing to the superior strength of the south-east trades that so much warm water crosses the equator from the South to the North Atlantic, etc., etc." (*id.* 230–231).

This reasoning seems to me to be eminently fallacious. In the first place, I know of no adequate evidence for the conclusion that the south-east trades are now stronger than the north-east trades. It is quite true that the belt of calms which separates the two trades is situated very largely north of the equator. But this, I urge very emphatically, is due to an entirely different cause, namely, the fact that the equator of heat of the earth is situated to the north of the real equator. I will on this point quote the lucid notice of Reclus: "The complete system of the winds," he says, "inclines towards the northern hemisphere, and it is to the north of the line that the girdle of the equatorial calms is in all seasons developed. This phenomenon, which might seem at first sight strange, results from the grouping of the greater part of the continental lands in the northern hemisphere, and from the difference of temperature, which must be, for our part of the world, the result of this unequal distribution of solid and liquid. It is also in the northern hemisphere that we find the Desert of Sahara, that immense extent where wooded tracts are relatively few, and where the reflection from the burning sands and rocks vaporizes the clouds which the atmospheric currents bring. The Sahara, and, in a less degree, all the tropical countries of the northern hemisphere, act as a great centre, towards which the aerial masses flow. It results from the tables drawn up by Dove that the mean temperature of the year is more elevated (92 Fahr.) towards the 10th degree N.L., than it is at the equator itself (91·5 F.) while the mean balance is stronger towards the 20th degree of Lat. (94 Fahr.) than in any other region of the world." Reclus adds: "The high temperature of the continents thus forces the southern winds to encroach upon the northern systems." (Reclus, *The Ocean:* translated by Woodward, I., 243-4.) This northern position of the equator of heat is not only the mean of its several movements, but we shall find, as a matter of fact, that it never goes south of the equator at all. "When the sun," says Reclus, "after the 21st of September, crosses the equatorial line to tend towards the tropic of Cancer, the centre of the trade winds, and consequently of the band of calms, moves at the same time towards the north; on the contrary, when the sun returns to the tropic of Capricorn, the most heated zone of air is gradually brought back to the south with the whole circulatory system of the trade winds. At the end of March the northern limit of the equatorial calms of the Atlantic is found on an average towards the 2nd degree of north latitude, while at the end of September the same limit attains ordinarily the 13th or 14th degree. As to the southern limit, it oscillates in the same ocean from 1 to 4 degrees of *north* latitude" (*id.* 292-3.)

Here, then, we have the real and efficient cause of the movement to and fro of the trade winds and the equatorial calms, and so long as the parallel of greatest mean heat, that is to say, so long as the furnace which causes the circulation of the trades remains to the north of the equator, so long will the south-east trades blow across the equator, not because of their greater potency, but because they must travel thither to reach the furnace which makes them move at all. This seems to be a complete answer to the main contention of Dr. Croll, which he states as follows:

". . . When the eccentricity of the earth's orbit attains a high value, the hemisphere, whose winter solstice occurs in aphelion has its temperature lowered, while that of the opposite hemisphere is raised, let us suppose the northern hemisphere to be the cold one, and the southern the warm one. The difference of temperature between the equator and the North Pole will then be greater than between the equator and the South Pole; according, therefore, to theory, the trades of the northern hemisphere will be stronger than those of the southern, and will consequently blow across the equator to some distance on this southern hemisphere. This state of things will tend to deflect equatorial currents southwards, impelling the warm water of the equatorial regions more into the southern or warm hemisphere than into the northern or cold hemisphere. The tendency of all this will be to exaggerate the difference of temperature already existing between the two hemispheres." (*Climate and Time*, 13-17.)

This position, it seems to me, fails at every point. The circulation of the trades does not depend on the difference between the temperature of the equator and the poles, for the warm equatorial winds and the cold polar winds each have a separate and distinct circuit of their own. There is no evidence that the south-east trades are stronger than the north-east, nor, if they were, that they could push back the region of equatorial calms, since, on reaching the parallel of greatest heat, they must move vertically and not laterally. On the other hand the fact that they blow across the equator is accounted for by the situation of the parallel of greatest mean heat being to the north of that great circle, which necessarily causes them to blow across the equator, and, what is more important, would do so long as that parallel remained north of the equator, however great the eccentricity of the earth.

What Dr. Croll has to prove in order to substantiate his position is, that during periods of greater eccentricity, when *our* winter took place with the world in aphelion, the equator of greatest mean heat was transferred to the other hemisphere, and that it has been subjected to an alternate movement north and south. That is to say, since the position of the equator of greatest mean heat is dependent upon the distribution of land and water, and the fact that in the torrid zone there is at present a larger proportion of land to water north of the equator than south of it, that this proportion was different in so-called glacial times, and that consequently there has been since those times a great revolution in the contour of the continents. Against such a conclusion the evidence of geology is very uniform, and it is in fact fully admitted by Dr. Croll himself, who, speaking of the so-called glacial epoch, says:—" Geologists almost all agree that little or no change has taken place in the relative distribution of sea and land since that epoch. All our main continents and islands not only existed then as they do now, but every year is adding to the amount of evidence which goes to show that so recent, geologically considered, is the glacial epoch that the very contour of the surface was pretty much the same then as it is at present." (*Climate and Time*, 9.)

We have not yet done, however. Dr. Croll does not argue that the warm equatorial current is diverted into the Temperate and Arctic seas by the direct action of the trade winds. He limits the direct action of those winds to first creating it and then pushing it bodily across the equator north or south, so as to confine it largely to one or other hemisphere, as the south-east or north-east trade winds prevail. It is quite clear, as he says, that the tendency of the trade winds is limited to impelling the intertropical waters along the line of the equator from east to west, and were those regions not occupied in some places by land, this equatorial current would flow directly round the globe. Its westward progress, however, is arrested by the two great continents, the old and the new. (*Climate and Time*, 210). It is the presence of these continents, and not the trade winds, which deflect these currents, and the latter move, after meeting with these barriers, along the lines of least resistance. The impetus, no doubt, which causes their movement is due to "the trades," but their deflection is due to the distribution of land and water.

As we shall show elsewhere, although there has been no change in this distribution since so-called glacial times which would shift the equator of heat to the south of the equator of the earth, there has been such a change (and a very slight one is needed) to affect the direction of some of the currents (after they have been deflected) by the land. What I wish to emphasize now is, that after the Gulf Stream has traversed the Gulf of Mexico and reached the Narrows of Florida, its course, instead of being from east to west, is from west to east, or rather from south-west to north-east, so is that of the main northern affluent of the equatorial current in the Pacific. That is to say, both of them reverse their direction at a certain part of their course and flow in a direction contrary to that of "the trades." Dr. Croll points out very clearly how this fact supports the theory of the wind-origin of ocean currents. He shows that in spite of the rotation of the earth, which would tend to give these currents a north-westerly direction, they flow eastward, because having reached the latitudes where the anti-trades blow from west to east, they are dragged along by them. (*Climate and Time*, 213.) This is quite true, but it seems to me to be a very fatal argument for Dr. Croll to use. If the Gulf Stream, and the corresponding Pacific current, owe the larger part of their later motion, and their consequent spread into far northern latitudes, to the anti-trades, and if the present climate of the northern hemisphere depends upon the extent of this spread, as Dr. Croll allows, then it follows that a more important factor than the trade winds which give the equatorial current its western motion, are the anti-trades, which give the resulting currents their north-eastern motion. The amount of heat distributed in high latitudes by these currents will depend not on the strength of the trade winds but on that of the anti-trades. We can scarcely doubt that, as the blowing of these winds is very uniform, and is limited to an area where the parallels do not differ greatly in length, while their distribution is very regular, the force of the anti-trades is very nearly that of the trades.

From this it follows that when the north-east trades are strong the south-west anti-trades must be strong also. Dr. Croll's main position is that during the so-called glacial epoch the north-east trades were so strong as to force a larger quantity of water across the equatorial line into the southern hemisphere, but this would be at once compensated for by the fact that the stronger anti-trade winds in the northern hemisphere would give the current which they induced a greater impetus and a wider distribution than the same current when under the pressure of the trades. If the north-east trades were very powerful so must the south-west anti-trades have been ; and if it were possible (as we have tried to argue it was not) for the former winds to push the equatorial current rather more to the *south* in the first part of its course, it must also have followed that the latter winds pushed them further *north* in the second part of its course, and the Gulf Stream must have been correspondingly faster and more widely diffused. In every way in fact, in which we approach the problem from the meteorological side, we must conclude that Dr. Croll's theory completely fails to satisfy the drastic demands of the evidence. Let us now turn to the more distinctly geological side.

Dr. Croll's, like some other theories, wholly or partially based upon astronomical evidence, includes the hypothesis that either hemisphere has been subjected in turn to glacial conditions, and that this alternating of glacial climates with temperate ones, has been the law of all time, and he, like Professor James Geikie, and others, professes to find evidence of this in the geological record. In addition, he has imported into the geology of the more recent periods quite a portentous system of chronology based upon the fact of recurring glacial periods coinciding with periods of extreme eccentricity, and postulates of hundreds of thousands of years have become quite an ordinary demand upon our credulity. As I cannot accept any of these conclusions, any more than I can his meteorological view, I must now devote a little space to their discussion.

In the first place, then, as to traces of a so-called glacial period in the southern hemisphere. The so-called glacial phenomena in the northern hemisphere are obvious enough. They need no microscope to discover them. They literally present themselves in every cubic yard of soil. Everywhere where they occur, boulders, or glacial clays and sands, or erratics, or arctic shells, are to be found, while mammillated rocks and scratches, etc., etc., are found everywhere on high ground. Nothing is more patent and nothing more obvious. This being so, it is clear that if the cause is a similar and recurrent one in either hemisphere, as urged by Croll, and those who maintain Croll's position, we must be able to support it, not only from one hemisphere but from the other. We cannot doubt that the very same cause, operating on the southern hemisphere, must have had the same or similar results to that operating on the northern one. We ought to find in the southern hemisphere, therefore, a state of things corresponding to that which is such a marked feature of the northern hemisphere, namely, a vast development of glacial phenomena, such as polished and rounded rock surfaces, striæ, erratics, and drift, not limited to a few valleys once occupied by large glaciers, but spread over an enormous area, and needing no microscope to discover them. Where are we to look for anything like this in the southern hemisphere, and especially in that part of the southern hemisphere which forms the *antipodes* to the North Atlantic district? We undoubtedly have at this moment with no excessive eccentricity a remarkable development of cold at the South Pole. With greatly increased eccentricity, if Dr. Croll's arguments are good, this ought to have been greatly increased, and especially ought it to have been so in the southern hemisphere, where there is so much water, and, consequently, so much evaporation. But where are we to look for it? In South America we no doubt have something resembling what we can find in boreal America: boulders, erratics, and scratched rocks, which have been described by Darwin, Agassiz, and others. But what of New Zealand, our *antipodes*, Australia, and South Africa?

It is quite true that there is ample evidence that both in New Zealand and Australia, there were formerly glaciers on a much greater scale than any now existing. On the other hand the testimony of most careful and competent observers is virtually unanimous as to there being no such traces of a glacial age in the southern hemisphere, as we find in the northern. As this is a matter of some moment, I must be allowed to quote some authority for my statement.

In regard to New Zealand, Haast, Hector, and Hochstetter are agreed that the evidence is clearly in favour of the former great extension of glaciers, and against any ice cap or any so-called glacial period. Haast, who once advocated the opposite view, abandoned it in 1864, and Hector writing in 1870 says, "The theory of an ice cap during the glacial period . . . is quite irreconcileable with observed facts, and the former extension of the glacier is sufficiently accounted for by the gradual reduction of the surface area exposed above the perpetual snow line: Firstly, by its erosion into valleys, ridges, and peaks; and secondly, by its gradual subsidence, a subsidence which has operated for the most part continuously, though interrupted by irregular and local elevations." (*Geol. Mag.*, VII., 95-6.)

In a paper by Captain Hutton (who studied the geology of New Zealand so well), which was printed in the 12th volume of the *Geological Magazine*, he absolutely denies the existence of evidence of the former existence there of a glacial period; he points out that at Wanganui, in Cook's Straits in New Zealand, there is the most extensive pleistocene shell-bearing bed on the island which has been well worked. From this bed 91 species of shells are known of which 81 are still living in the seas of New Zealand. "There is, therefore," he says, "no evidence of reduction of temperature in the early part of the pleistocene period."

Below this pleistocene bed is a blue clay in which 98 species of shells have occurred. Of these 77 still inhabit the

New Zealand seas and Captain Hutton consequently attributes them to the newer pliocene period. He says again : "I have travelled over and mapped the whole of the province of Otago and I have met with no stratified till, or any marine beds intercalated between glacial or glacier deposits; although since the pleistocene period the land has been undergoing elevation. On the whole, therefore, the evidence is decidedly against the idea that a colder climate formerly obtained in New Zealand . . . As New Zealand is nearly antipodal to Great Britain, any change of climate in one place, caused by a change in the position of the earth's axis of rotation, would also necessitate a similar change in the other place." He concludes : "There is no evidence whatever of a glacial epoch having occurred in New Zealand, although, if it had occurred, there is every reason to expect that it would have left sufficiently clear traces behind it. Professor M'Coy has also come to the conclusion that there was no glacial epoch in Victoria. He says all our evidence in fact goes to show that there was no glacial epoch in Victoria succeeded by a warmer modern one, but there has been a regular and gradual falling of the temperature to the present day." (*Annals Nat. Hist.*, 3rd Ser., Vol. XX., 194.)

Mr. R. von Lendenfeld tells us in a paper read before the Geological Society of London in April, 1885, that it is only in the highest ranges of the Australian Alps that he could find traces of ice action. No traces of ice action could be found below 5,800 feet above the sea. This shows the traces are of old glacier action and not of a glacial period. (See *Geol. Mag.*, Sec. III., Vol. II., p. 281-2.)

What is true of New Zealand and Australia is true also of Tasmania. I might continue, but this evidence, in which all the most experienced geologists who have worked in the Australian region concur, will suffice to show that there is nothing in this part of the southern hemisphere corresponding to the glacial phenomena so conspicuous in the northern one, and this fact is fatal to such theories as Dr. Croll's, which are based upon the recurrence of similar conditions in either hemisphere alternately. The only evidence we have from the southern hemisphere, and of that there is abundance, goes to show that local glaciers were then developed on a much larger scale than now, and coexisted alongside of a similar vegetation now prevailing, proving anything but a critical change of climate.

Again, the evidence of the local geologists is almost, if not quite unanimous that these glaciers were the immediate precursors of the present ones, and that neither the remains of the fauna, nor the loose deposits, justify any other conclusion than that the great development of the southern glaciers was contemporaneous and did not alternate with the great development of the northern glaciers, and neither preceded nor was subsequent to it.

On this point Agassiz is very emphatic—

"I have not noticed anything to confirm the idea that the glaciers of the northern hemisphere have alternated with those of the southern hemisphere in their greatest extension, as is assumed by those who connect with the precession of the equinoxes, the difference of temperature required for the change. The abrasions of the rocks seemed to me neither more nor less fresh in one hemisphere than in the other; nor do the veins of molten rocks rising above the surrounding disintegrating rocks stand out in a more or less bold relief in either case. However astronomical causes may have been connected with the climatic conditions of the world, I see no reason for believing, from any facts I have observed, that alternations of temperature in the northern and southern hemispheres have ever been the primary and efficient causes of glacial phenomena." (*Nature*, vol. VI., p. 272.)

Mr. Belt says: "I think it highly probable that the evidence that is accumulating will force geologists to the conclusion that the ice of the glacial period was not only more extensive than has been generally supposed, but that it existed at the same time on the northern and southern hemispheres, leaving, at least on the American Continent, only the lower lands of the tropics free from the icy covering" (*id.*, 264–5). Mr. Belt again says: "The glacial periods probably existed in both hemispheres at the same time. First, because we can trace the evidence of the existence of ice along the high lands of America into the northern tropics until it nearly inosculates with that coming down from the south, and there is no difference in the character or appearance of the moraines left on both sides of the equator. Second, because, except on the supposition that the ice extended at least along some meridians, both from the south and the north, nearly to the equator at the same time, we cannot explain the distribution of those annuals and plants that are found in the temperate zones of both hemispheres, separated by the whole width of the tropics, over which they cannot now pass. For example, there are more than forty flowering plants of North America and Europe, which are also found in Tierra del Fuego. Darwin's theory, that these plants were driven to the high lands of the tropics during the glacial period, and followed the retreating ice in its retrocession, must fall to the ground if the ice did not exist in both hemispheres at the same time." (*Nature*, X., 25 and 26.)

Nor is this alternating theory supported by an appeal to what we know of other bodies than the earth, which have an orbit of marked eccentricity, and are therefore in a condition like the earth must have been during the supposed glacial period. Fortunately, as Professor Bonney has suggested, it is easy to make such an appeal. The planet Mars, so far as we can gather, is constituted like the earth. We can trace out its land area and its seas, and also see its atmospheric effects. Among other things which it contains are two white polar caps. These were observed by Herschell to shrink and enlarge with the seasons, and there can be little or no doubt that they represent the ice at either pole of Mars. Now, in addition to its physical resemblance to the earth, Mars fulfils the conditions demanded by Dr. Croll, namely, its orbit shows great obliquity, yet nothing is more certain than that the results suggested by Dr. Croll are not forthcoming. We have not one pole with a gigantic icecap, and the other denuded of ice, but both poles have a more or less similar covering, and more or less of the same size, showing coincident and not alternate conditions of extreme cold at each pole.

This being the recent and contemporaneous evidence furnished by the two hemispheres as to alternate glaciation, what do the older beds have to say in regard to an alternation of cold and warm periods?

Let us remember what kind of evidence we ought to have if we are to believe in a recurrence of such conditions as are evidenced by the drift phenomena. As I have already said these phenomena need no microscope to discover them. They are among the most stupendous and the most cosmopolitan monuments furnished by geology. Within the geographical limits of the drift phenomena we can hardly examine a rood of ground without finding traces of them either in the striated boulders, scratched rocks, clays, muds, or in the animal remains. They are present everywhere, and most of them are among the most indestructible of witnesses. Where can we find at any geological horizon facts to parallel these? The earth has been diligently searched for them, but with the exception of a few uncertain and sporadic and dubious cases of the occurrence of some boulders in old conglomerates, which are compatible with other explanations, where are we to look for evidence? What a strange thing is this! If the so-called glacial age has been a recurring one in all geological time, assuredly we ought to find at every horizon not merely evidence, but unmistakeable proof. We have not to do with fragile materials which could be destroyed by denudation, but with tough boulders, with rounded land-surfaces on crystalline rocks, etc., etc. Nowhere, except as I have mentioned, is this forthcoming, but the contrary. The evidence of the animal and vegetable débris again, of which we have so much from every horizon, is perfectly consistent with that of the lithology and consistent in protesting against a theory which makes so many demands on our credulity, and especially is this true, as has been well observed, of the Tertiary beds and the vast period of time they cover. It is quite true that certain traces have been found in some Permian beds, which have been quoted by Ramsay and others, and which seem to point to ice action, but ice action does not mean the existence of a glacial period. Glaciers probably always existed as they exist now where the land was sufficiently high, and we ought to find traces of them in the geological record. What is wanted, however, is not testimony to sporadic glaciers or local ice action, but to widespread glacial phenomena such as would witness an ice age.

On this question let me quote two authorities of the first rank:—

Sir Charles Lyell, after examining the evidence in some detail, concludes thus: "If it be asked whether in the entire miocene series there are no indications of intercalated spells of colder climate like the glacial episode intervening between the older pliocene and the modern era, I may reply that there are none which can at present be established on organic evidence." (*Principles*, 1867, 204.)

Again, speaking of the same kind of evidence, he says some indications seem also to have been discovered of intercalated glacial periods, especially in the miocene, pliocene, and permian eras, but no decided changes in the character of the organic remains have yet been shown to accompany the inorganic proofs of supposed glacial action of those remoter periods (*id.* 202).

Again, he says: "If the sketch we have given in the tenth and eleventh chapters of the former states of climate revealed to us by palæontological research be an approximation to the truth, it will be at once seen that glacial periods have not been perpetually recurring in the northern temperate zone, as they ought to have done were a large eccentricity alone sufficient, apart from the co-operation of all other causes, to intensify the cold of high latitudes. It was shown that the flora and fauna do not exhibit signs of violent revolutions from hot to cold and from cold to hot periods. On the contrary, the continuity of forces, particularly in the class of reptiles, from the Carboniferous to the Cretaceous period, is opposed to the intercalation of glacial epochs corresponding in importance to that of post-pliocene date. During the Carboniferous period there must have been a long suspension in the temperate latitudes of the northern hemisphere of cold such as we now experience. An equable climate must have endured for a lapse of centuries, sufficient to allow several giant cycles of eccentricity to be gone through. But we do not find in strata of that age 15,000 feet thick in Nova Scotia any proofs of such intercalated glacial epochs. The peculiar vegetation of the coal was persistent throughout the greater part of the ages required for the deposition of so great a thickness of sediment in which one forest after another was buried on the spot where it had grown" (*id.* 299).

On the same question, Professor Prestwich, who is *facile princeps* among English authorities on the tertiary period, speaks even more emphatically:—"Dr. Croll shows," he says, "that in the three million years for which his tables are computed there were five periods during which the eccentricity was as great or greater than during the glacial epoch proper; so that taking the geological time at the hundred million years, at which he estimates it, there should have been in all probability some 165 such periods of cold. With the exception of the permian, which is still *pendente lite*, where is there any evidence of any such cold periods?"

In regard to the evidence of the so-called miocene beds quoted by Dr. Croll, from North Italy, Mr. Prestwich says: "The fact of the miocene date of the beds in question has never since been confirmed; all the later evidence tends to show that it was not until towards the close of the pliocene period that glacial conditions set in."

"For the pliocene period Dr. Croll relies on another Alpine case, the coarse conglomerates with some enormous blocks forming the Flysch. But this was a period of Alpine disturbance and change, when, though the rocks may have been rent and worn down in the mountain area, the marine life at a short distance gives evident indication of a high general temperature. Nummulites then abounded in the surrounding seas, together with echinoderms of a decidedly tropical aspect.

"The case for the chalk is still weaker, for the very few and exceptional foreign rock boulders that have been found in it are of small size, such as might have been carried in the roots of trees, or by sea weeds, or possibly by small winter ice rafts from the mountains of Scandinavia or the Ardennes, while all the life of the Cretaceous sea is strictly that of temperate, if not of warm latitudes. The small pebbles may have been carried by the large marine reptiles."

Speaking of the mass of granite rock found by Godwin Austin imbedded in chalk at Croydon, Mr. J. Gunn says, "it exhibits no more than the washing of the land by floods, or inroads of the sea, ... *such masses are rounded* *and afford no proof of ice action.*" (*Geol. Mag.*, "Decade III.," Vol. 1, p. 74). To revert to Mr. Prestwich—

"It is on facts of the same character as those which Dr. Croll adduces for the pliocene period that he would have found evidence of the action of ice in Scotland during the oolitic period; but we must seek for some other explanation to account for the incompatible fact that at those times warm conditions of climate extended to 70°—80° north, and that corals, Cephalopods, and huge reptiles swarmed in the seas." I would add that, so far as I know, no striated boulder has ever occurred in the oolitic rocks.

"Nor is it easy to admit a claim for ice action during carboniferous times when the luxuriant vegetation of the coal measures flourished not only here but on Bear Island and other northern lands. With respect to the blocks of granite alluded to as occupying the lower beds of the coal measures in France, they may be, like the tors of Cornwall, blocks left *in situ* from the decomposition of the granite on which the coal measures there rest, or they may be boulders washed down at that period by the torrents from the adjacent granite mountains. Other foreign pebbles may be accounted for as we have accounted for those in the chalk." (*Quart. Jour. Geol. Soc.* for August, 1887.)

In a paper on certain boulders of quartzite found actually imbedded in a coal seam in Leicestershire, Mr. W. S. Gresley collects a number of other instances of their occurring in coal measures from other localities, and shows that these rounded and water-worn boulders were the débris left by currents of water, and he argues that they were dropped or washed out of the roots of trees as they were floated along in flood time from higher ground on which they grew. (*Geol. Mag.*, "Decade III.," Vol. II., 553–555.)

Professor V. Ball again writes, "Angular fragments of granite and of schist, quartzite, and reinquartz have been discovered in beds of carboniferous limestone near Dublin."

Dr. Croll quotes these as evidence of ice transport, but says Mr. Ball, "the specimens exhibit none of the indications of glacial conditions, whether we regard the character of the boulders or the nature of the rock in which they are imbedded." (*Geol. Mag.*, "Decade III.," Vol. V., p. 232.) Again returning to Mr. Prestwich—

"There are similar palæontological objections to ice action in the Devonian and Silurian periods. Although there may be at times instances in which the blocks show striæ, and are derived from rocks not known in the locality, it must be borne in mind that such striated masses may be fragments of slicken side surfaces in the rocks from which the breccias are derived ; and that, although a particular rock may no longer show in the locality, it may exist there buried beneath newer deposits, as, amongst others, in the case of the granite of the Ardennes, which, although formerly unknown there, was met with in a railway cutting beneath a slight covering of Palæozoic rocks.

"Admitting the imperfection of the geological record, it is evident that, as a whole, the physical instances fail entirely to supply any sufficient corroborative evidence, either in force or in number, to support the theory of recurrent glacial periods. Surely out of 165 or even 100 cases, more definite marks would have been left, especially in the more recent periods, such as the pliocene and miocene, when the land had assumed many of its present contours." (*Quarterly Journal, Geol. Society* for August, 1887.)

I will now quote another first rate observer, who is speaking of the polar area, where, if anywhere, traces of intercalated glacial periods ought to be forthcoming :—

In an elaborate paper published in the *Geological Magazine*, entitled "Former Climates of the Polar Regions," Nordenskiold says, *inter alia :* "From what has been already stated, it appears that the animal and vegetable relics found in the polar regions imbedded in strata deposited in widely separated geological eras, uniformly testify that a warm climate has in former times prevailed over the whole globe. From palæontological science no support can be obtained for the assumption of a periodical alternation of warm and cold climates on the surface of the earth" (*op. cit.* Vol. XII., 531). Again, he says: "A careful investigation of the structure of the different sedimentary strata leads to the same result. We are now very well acquainted with the origin and nature of the various strata, the substance of which has been supplied by the destructive operation of glaciers on the surrounding and subjacent mountain masses, and we can point out certain marks by which these strata may be distinguished from other non-glacial deposits. In these last one very rarely meets with any large stone boulders, which have fallen from some neighbouring cliff, and been imbedded in sand or clay, either directly, and if so close to the place where originally found, or else after having in the spring been moved a greater or less distance by river ice. In glacial formation, on the contrary, as one may gather from the study of the strata in Scandinavia that belong to the glacial period, erratic blocks transported on icebergs to far distant regions play an important part. If a climate similar to that which now prevails in the Arctic regions has several times during various geological eras existed in the neighbourhood of the Pole, one has reason to expect that sandstones enclosing large boulders should often be met with in these tracts. But this is by no means the case, though such formations, if they exist on a large scale, could hardly escape observation.

"The character of the coasts in the arctic regions is especially favourable to geological investigations. While the valleys are for the most part filled with ice, the sides of the mountains in summer even in the 80th degree of latitude, and to a height of 1000 or 1500 feet above the level of the sea, are almost wholly free from snow. Nor are the rocks covered with any amount of vegetation worth mentioning, and, moreover, the sides of the mountains on the shore itself frequently present perpendicular sections, which everywhere expose their bare surfaces to the investigator. The knowledge of a mountain's geognostic character, at which one in more southerly countries can only arrive after long and laborious researches, removal of soil and the like, is here gained almost at the first glance; we have never seen in Spitzbergen, or in Greenland, in these sections often many miles in length, and including, one may say, all formations, from the Silurian to the tertiary, any boulders even as large as a child's head. No strata containing boulders are to be found in the Polar tracts previously to the middle of the tertiary period.

"Since, then, both an examination of the geognostic condition, and an investigation of the past flora and fauna of the polar lands, show no signs of a glacial era having existed in those parts before the termination of the miocene period, we are fully justified in rejecting, on the evidence of a clear observation, the hypothesis founded on purely theoretical speculations, which assumes the many times repeated alternation of warm and glacial climates, between the present time and the earliest geological ages" (*id.* 531-2).

The convergence of evidence is irresistible, therefore, in regard to the absence of substantial evidence of alternating climates in the older deposits, and the best proof of this is the way in which the advocates of this theory virtually neglect the vast field of inquiry which lies open to them in the whole range of sedimentary strata from the cambrian to the end of the tertiary period, and converge their artillery upon the testimony of the so-called glacial beds themselves, the latest chapter only in geological history.

In regard to the evidence of so-called glacial beds, I wish to say most emphatically that it is most unsafe and most dubious. We have not yet found a key by which we can give a rational explanation of the true succession of so-called glacial deposits in two adjoining counties, much less in two larger geographical areas. Nowhere do we meet with clearer proof of tumultuous and disorderly deposit than in these beds of boulder clay without stratification, and in these local beds of intercalated sand, with their lines of deposit twisted into every conceivable form of curve and eddy. In many places we have no sands at all, in many very large areas we have no boulder clay at all, and yet the accidental occurrence of packets of stratified sands or loam, sporadically distributed, is held to prove an interglacial climate.

Dr. Croll describes the so-called glacial epoch as consisting of a succession of cold and warm periods, the cold periods of one hemisphere coinciding with the warm periods of the other, and *vice versa.* (*Climate and Time*, 234.) As Professor Prestwich says, however:—"This would involve an indefinite succession of interglacial periods, but only one definite interglacial period during the glacial epoch is brought forward." Dr. Croll, however, accounts for this on the grounds that "the geological evidences of the cold periods remain in a remarkably perfect state, while the evidences of the warm periods have to a great extent disappeared" (*id.* 238). "If, however," continues Mr. Prestwich, "one instance would be well preserved, might we not expect other instances to occur in some of the many localities affected?" I would add that the molars of mammoths, the leg bones of oxen and horses are not more fragile than arctic shells and the leaves of arctic plants. "Dr. Croll estimates the average duration of a warm period at about 10,000 years. Supposing such to have been the case, the phenomena of the glacial series certainly afford no corroboration of the remarkable vicissitudes of climate this would infer." (*Jour. Geog. Soc.*, Aug. 1887.) Again Mr. Prestwich says, "It is to be observed also that there is no evidence in North America of an interglacial period in the sense of the one supposed to have existed in Europe" (*id.*).

Mr. Searles Wood, junior, an explorer of great experience says, that with the exception of one warm interval marked by beds containing cyrena fluminalis, he has "not been able to discover any indication of those alternations of warm and cold climate which form an indispensable part of the eccentricity theories of Adhemar, Croll, Murphy and others." "In the case of North America there has also been a failure altogether, on the part of the geologists of that country, to detect evidence of more than one alteration of climate during the glacial period." (*Geol. Mag.* "Decade II." X. 294).

The evidence of life is still more unsatisfactory. Professor James Geikie, in his address at Newcastle, recurred to views, which I thought were extinct, about the deposits containing reindeer and other boreal animals being of a different age to those containing austral forms. How can this be, when all over France, Germany, and South Britain we not only find reindeer bones mixed with those of the hyæna; but as Professor Dawkins has shewn, gnawed by hyænas, when we meet with the leaves of the arctic willow mixed with those of the canary laurel and the fig, to mention only two facts out of a great many which may be found collected in a book which I have published, entitled "The Mammoth and the Flood." There is no evidence known to me which can be derived either from the animal or the plant remains in the drift deposits which would justify recourse to a theory of alternating climates, and the cases which have been cited are, it seems to me, entirely irrelevant. No doubt mammoth's teeth and remains of other animals, his contemporaries, have sometimes been found over and sometimes under boulder clay. This fact, no doubt, needs explanation, and can, I believe, be completely explained by an entirely different cause, as I shall endeavour to show elsewhere. It certainly does not as I hold support the theory of interglacial warm climates. If alternating climates had occurred throughout all time no fact would be so patently and clearly attested by plant and animal remains, which form the best weather gauges we can obtain. Boulders, scratched rocks, etc., are naturally indestructible, and, if anything like a so-called glacial epoch had existed during the enormous development of the tertiary period, we should assuredly have found something to correspond to the vast beds of rolled and unrolled stones, the erratics, the till and the sands, which so unmistakably mark the last geological age in these latitudes, nor would the *roches moutonnées*, etc., be so conspicuously absent. We should not have been driven to base our conclusion on the existence of a few sporadic stones, with scratches from some local bed of permian conglomerate, or be perpetually referred to the brown coal deposit in that very difficult geological area Zurich. We should not have had the advocates of such a theory feverishly quoting and requoting these particular threadbare instances, so limited both in quantity and in its geographical distribution, and proving, as I contend, an entirely different conclusion. We should rather have had evidence pouring in upon us from all sides, especially from such undisturbed areas as the plains of Russia and North Europe. As a matter of fact, we may traverse nearly all the known world in the southern hemisphere, as well as the northern, and whether we use the fauna and flora as a test and measure of climate, or whether we use the more solid and indestructible stony débris, we shall fail to find evidence adequate to support the gigantic hypothesis, that the earth has passed through a cycle of glacial and temperate periods alternating with each other, and it seems to me that it is only by focussing our attention on very limited and small areas, and applying our induction from them to whole continents, that it is possible to maintain hypotheses so little supported by evidence.

It follows, therefore, from a general survey of the position, that neither on meteorological, geological, nor palæontological grounds can Dr. Croll's theory be maintained, and that the evidence is conclusively opposed to the glacial theory as presented by him, and is especially against the notion that such a glacial period has been a recurring event in geological history.

Ordinary Meeting, November 26th, 1889.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

The PRESIDENT reported on behalf of the Council that the effort to obtain a Public Meeting, to promote the erection of a permanent memorial in Manchester of Dr. James Prescott Joule, had been responded to in the most encouraging and even enthusiastic manner; that upwards of three hundred and forty residents, including those most influential, had signed a requisition to the Mayor; that the Mayor (Mr. Alderman Mark,) had shown the greatest interest in the matter, not only by lending his Parlour in the Town Hall, and presiding, but by addressing the meeting, which had been held on November 25; that the meeting had been large and influential, and that many letters had been received from those persons who were unavoidably absent, supporting the movement and promising help; that Mr. Oliver Heywood had moved the following resolution:—

> "That this meeting desires to mark its deep sense of the benefits conferred on mankind for all time, as well as of the honour which has accrued to this district, by the scientific work of the late James Prescott Joule, by the erection of a durable memorial of him in Manchester, in the form of a white marble statue,"

which had been adopted; that a large committee had been appointed to carry on the work, with the Mayor of Manchester as chairman, and Mr. Oliver Heywood as treasurer; and that the Joule Committee appointed by the Council had now discharged its duties.

Mr. W. E. HOYLE, M.A., M.R.C.S., exhibited specimens of cuttle-fish from the Challenger collection, which have been under examination by him preparatory to being sent to the British Museum. Some of the specimens were unique, and others from parts of the world in which they were, previously to the Challenger expedition, unknown. Three specimens of a genus only known previously on the coast of Greenland were found in different parts of the world, while of a genus only known to live in crannies in rocks, specimens were found in the Pacific Ocean, in deep sea, and of deep-sea characteristics.

Dr. JAMES BOTTOMLEY read the following "Note on the Rate of Dissolution of Solids":—

"In a paper read before the Society in February of this year I considered the rate of dissolution of a solid placed in a menstruum capable of dissolving it; in all the cases considered the rate of action was supposed to be the same along every normal. But we may have to deal with solids in which this latter condition is not fulfilled. Generally the expressions to be integrated will become more complex, but if the solid be bounded by plane faces the investigation will be simplified. For example, suppose we have a parallelopiped of which the edges at any instant are x, y, z. Then V and S, being volume and surface, we shall have

$$\mathrm{V}=xyz \qquad (1)$$

$$\mathrm{S}=2(xy+yz+xz) \qquad (2)$$

After the lapse of time dt the edges will become $x-2dx$, $y-2dy$, $z-2dz$, hence we have

$$dv=-2(xydz+yzdx+xzdy) \qquad (3)$$

Let m be the ratio of the velocity along the axis of y to that along the axis of x, and n the ratio of the velocity along the axis of z to that along the axis of x, so that we may write

$$dy=mdx, \quad dz=ndx.$$

Integrating these equations, we get

$$y=mx+p \quad z=nx+q$$

p and q being constants to be determined by the initial length of the edges. Substituting these values in (1), (2), (3), we get

$$\begin{aligned} V &= x^3mn + x^2(pn+qm) + xpq \\ dV &= -2dx(3x^2mn + 2x(pn+qm) + pq) \\ S &= 2\{x^2(m+n+mn) + x(p(1+n) + q(1+m)) + pq\}. \end{aligned}$$

If such a solid were subject to the same conditions of dissolution as were assumed in the paper referred to, the differential equation would assume the form,

$$\frac{(3x^2mn + 2x(pn+qm) + pq)dx}{x^3mn + x^2(pn+qm) + xpq + r} = -l\{x^2(m+n+mn) + x(p(1+n) + q(1+m)) + pq\}dt.$$

When the arithmetical values of the letters p, q, m, n are assigned this expression may be integrated, and the dimensions of the parallelopiped at any time determined. The above expression will be simplified if certain relations coexist among the constants; for example, if we have the relations

$$\frac{p}{m} = \frac{q}{n}, \quad 2mn = m+n$$

the equation takes the form

$$\frac{dx}{x^3mn + x^2(pn+qm) + xpq + r} = -ldt.$$

Also we may have the relation $p=0$, $q=0$; in this case the parallelopiped at any instant will be similar to its initial form, a condition which would probably hold in the dissolution of some crystalline forms; in this case the equation assumes the much simplified form

$$\frac{3dx}{x^3mn + r} = -l(m+n+mn)dt.$$

From this expression for the velocity, the other circumstances of dissolution would admit of easy determination by integration. In the previous paper, page 166 (*Mem. and*

Pro. Man. Lit. and Phil. Soc., Vol. II., 4th Series), the line normal to the instantaneous surface is written in the form

$$\frac{X-x}{c}=\frac{Y-y}{c}=\frac{Z-z}{c}$$

the equations should be

$$\frac{X-x}{\cos\alpha}=\frac{Y-y}{\cos\beta}=\frac{Z-z}{\cos\gamma},$$

α, β, γ being the direction angles.

Mr. J. J. ASHWORTH enquired whether any explanation had been given of the cause of formation of the "Levanter Clouds" at Gibraltar which he had lately seen. During the continuance of the east wind blowing from the Mediterranean Sea—a dense black cloud is formed to the west of the rock of Gibraltar over the town and bay. This cloud can be seen forming from below, as there appears to be for a distance of some 40 or 50 yards from the top edge of the rock a perfectly clear space through which the sky can be plainly seen before the cloud begins to appear, and about half-way across the bay the cloud seems to be absorbed again, having a rather curious effect. The vapour of which the cloud consists appears to be in continual motion from east to west. Early in the morning there is very little of it to be seen, but it gradually increases in density up to the middle of the day, when it appears perfectly black, and hangs like a pall over the town and bay, having a most depressing effect on the inhabitants of the rock. Mr. Ashworth added that he understood that it was found to be very unhealthy, as the sick rate always increases during its presence. There is very little, if any, deposit of rain, and the streets and town are smothered with fine dust, which renders the presence of this "Levanter cloud" very obnoxious.

The PRESIDENT explained generally the formation of clouds on the lee side of a hill, as caused by the existence of a point of minimum pressure at some point below the brow of the hill. In the case referred to there is probably a disposition to formation of clouds, as the clear air from the sea there for the first time meets with dust and smoke, which, as Aitken has shown, even in minute quantities, fosters the formation of cloud in a moist atmosphere.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, December 2nd, 1889.

Dr. ALEX. HODGKINSON, Vice-President of the Section, in the Chair.

Mr. P. CAMERON made a communication on the *Cynipidæ* of the Manchester district. There are 36 species known in Britain, and of these he had found 26 species in this district.

Ordinary Meeting, December 10th, 1889.

EDWARD SCHUNCK, Ph.D., F.R.S., F.C.S., Vice-President, in the Chair.

A large photograph of the late Dr. J. P. Joule was exhibited by Mr. A. BROTHERS, and was very favourably spoken of by the Chairman and other members.

Dr. SCHUSTER gave an illustration of the apparent ignorance even in scientific circles of much of Dr. Joule's work. It had been observed that long magnetic needles give a bigger dip than short ones, and in a paper read before the Society Dr. Joule explained the phenomenon as due merely to the bending of the needle by its own weight. The Greenwich records, however, still give the various readings of needles of three different lengths, and it is an axiom in observatories that long needles give a bigger dip than short ones, no one outside Manchester apparently being aware of Dr. Joule's explanation.

Dr. HODGKINSON exhibited a specimen of iridescent chlorate of potash mounted in a special way in order to demonstrate that the colour is produced, not by the interference of one thin plate, but by numerous thin plates. The thin plates were readily seen in the specimen by means of a hand magnifier, and the exhibit confirmed a prediction made several months since by Lord Rayleigh.

Mr. FARADAY adversely criticised the latest Blue-book issued by the Solar Physics Committee. He called attention to the absence and confusion of dates and signatures, the imperfection of the references, and the want of continuity with the previous report. The Committee had been in existence since 1879, and it had only issued two reports. The first had been compiled seven years previously, and the second had just appeared. Mr. Faraday complained that the spectroscopic work described did not appear to be the work which the Committee was appointed to carry on, and that the report did not present the results which the practical reader hoped to find in it. A discussion on the desirableness of the abolition of the Committee, in which Mr. H. H. Howorth, M.P., took part, ensued.

Professor DIXON read a paper on the combination of hydrogen and chlorine alone and in the presence of other gases. An apparatus was exhibited whereby the gases can be measured and exploded without coming in contact with any liquid. A protracted discussion ensued, in which Dr. Schunck, Dr. Bottomley, Mr. Francis Jones, Professor Schuster, and others, took part.

On the combination of Hydrogen and Chlorine, alone, and in presence of other gases. By Harold B. Dixon, M.A., F.R.S., Professor of Chemistry, and J. A. Harker, Research-Student in the Owens College.

(*Received December 27th, 1889.*)

Is the combination of hydrogen and chlorine affected by the presence or absence of moisture? Does hydrogen, when exploded with an excess both of chlorine and of oxygen, unite entirely with the chlorine or divide itself between the two?

The evidence on the first point is conflicting; on the second we have the definite statement of C. Bötsch (*Annalen* 210, p. 207) that the hydrogen does not divide itself between the chlorine and oxygen, but goes entirely to the chlorine. Bötsch's experiments, however, are not accurate enough to make us feel sure of his conclusion, which he admits is *à priori* improbable.

In a communication made to the Chemical Section of the British Association at Newcastle last September, we brought forward some evidence bearing on these questions. Our object was to work out the law according to which hydrogen divides itself between chlorine and oxygen in an explosion of the three gases. It was first necessary to determine whether direct union between dry hydrogen and chlorine takes place under the conditions of our experiments. We found that sparks from an induction coil, passed through the gases between wires of platinum-iridium, caused the instantaneous explosion of the mixture after it had been standing for days in contact with anhydrous phosphoric acid. Combination between dry hydrogen and chlorine is therefore determined by the spark, just as combination between dry hydrogen and oxygen is determined by the spark.

On the other hand, the action of light on a mixture of hydrogen and chlorine is affected by the presence of moisture. In the course of our experiments on hydrogen and chlorine (which were begun in 1882) we have on several occasions noticed the difficulty of exploding dry hydrogen and chlorine by a flash of light. The same observation has been made by other chemists, of whom we may mention Mr. W. A. Shenstone. But the fact was not, so far as we know, published until 1887, when Pringsheim,* in his admirable paper on the chemical action of light on hydrogen and chlorine, stated that the mixture when long dried by phosphoric acid exploded only after a few seconds in sunlight and with a weak clicking sound; and that in diffused daylight the formation of hydrogen chloride was greatly retarded.

In order to compare the action of light on the wet and dry mixture of hydrogen and chlorine, we filled a row of six bulbs with the electrolytic gas, and sealed them up. In the last two bulbs plugs of anhydrous phosphoric acid were placed, so that the gases were sealed up in contact with the drying agent. After lying in the dark some weeks, a wet and a dry bulb, screened one from the other, were exposed to the light of a magnesium "flash" placed six feet from the two. Neither exploded; but on firing a similar flash five feet from the two, the wet bulb exploded loudly, the dry bulb was unaffected. On firing flashes at 4 and 3 feet from the dry bulb, no action was observed. Fired at 2 feet from the dry bulb, the flash produced a loud explosion. In other experiments similar results were obtained. When the electrolytic gas was well dried before admission to the bulb,

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[Annalen der Physik, 1887. N.F., xxxii., p. 421.

and was then sealed up with phosphoric acid, and kept several weeks, it could not be exploded by the flash at 1½ feet. We may state, as a general result, that a magnesium flash (which will invariably explode a wet mixture of hydrogen and chlorine at 5 feet distance) has to be brought within one foot in order to explode a well dried mixture of the same gases; in other words the intensity of the light must be increased 25 times to produce the same effect on the dry as on the moist gases. This difference in the action of light is so well marked that we have continually made use of it as a test of the dryness of the electrolytic gas used in our experiments on the volume-relation of hydrogen and chlorine to the hydrogen chloride gas formed from them.

To determine the law which regulates the division of hydrogen between chlorine and oxygen, in an explosion of the mixed gases, it is essential that the gases should be accurately measured. All our attempts to measure chlorine in a eudiometer over a liquid have failed. Oil of vitriol (used by Bötsch) absorbs chlorine; liquid chlorinated hydrocarbons absorb chlorine rapidly. We have had to measure chlorine by filling a glass explosion vessel of known capacity with it under known conditions; and have then introduced into the same vessel known volumes of hydrogen and oxygen. Our latest apparatus consists of two strong bulbs (of 180 c.c. and 140 c.c. capacity), which can be put into communication through a wide tap. Each bulb can be filled separately; for instance, one may be filled with electrolytic hydrogen and chlorine and the second with oxygen, or one may be filled with electrolytic hydrogen and oxygen and the second with chlorine. The two bulbs are then put into communication, and the gases allowed to mix by diffusion. A pressure tube is attached to the bulbs, and is shut off by a stopcock. This tube is filled with an inert gas, *e.g.* nitrogen, and dips into a mercury trough. When all is ready for an explosion the tap of the pressure tube is opened for a moment and then closed. The height of the mercury in the tube gives the pressure in the bulbs. By having the gases in the bulbs slightly below the atmospheric pressure a little nitrogen from the pressure tube enters the bulb and no chlorine escapes into the pressure tube. After firing at a suitable temperature the temperature can be reduced to the same point as before. Then on opening the tap of the pressure tube the rise of mercury indicates the diminution in volume of the exploded gases. If hydrogen and chlorine united without contraction to form an equal volume of hydrogen chloride gas, and if the hydrogen united entirely with the chlorine and not with the oxygen at all, then no alteration in volume would result from the explosion.

However, on firing the well-dried mixture of the three gases by a spark at ordinary temperatures, a *cloud* is formed, and a considerable *contraction* is shown by the pressure tube. We have found a contraction of over 10 per cent of the original volume of gases—*due partly to the formation and condensation of steam, and partly to the formation of hydrogen chloride and to its solution in the water condensed.* We say that the condensation is partly due to the formation of hydrogen chloride, because we have found that however carefully the bulbs and the gases are dried, there is a sensible contraction when hydrogen and chlorine combine in a glass vessel. This contraction is rather over 1 per cent of the original volume. We have varied the apparatus and the manner of working, but we always find nearly the same result—whether the gases are exploded or whether they combine gradually in diffused light.

The fact that the hydrogen *divides* itself between the chlorine and the oxygen is proved by the large contraction, by the cloud, and by the visible drops which condense on the surface of the bulb.

Proof of another kind is afforded by the fact we have established that chlorine is liberated when hydrochloric acid is mixed with equal volumes of hydrogen and oxygen and the mixture is exploded. The excess of heated oxygen takes hydrogen from the hydrogen chloride under these conditions which are comparable with those obtaining when a mixture of hydrogen, chlorine, and oxygen is exploded.

We are now engaged in measuring the proportions of hydrochloric acid and steam formed under conditions when the products of explosion are kept within the sphere of chemical action. Since our communication was made at the Newcastle meeting, and after a brief account of it had appeared in *Nature* (October 10), a paper was published in the *Comptes-Rendus* (October 21) by MM. Hautefeuille and Margottet—"Sur la synthèse simultanée de l'eau et de l'acide chlorhydrique." These authors find that hydrogen divides itself between chlorine and oxygen, unless the volume of chlorine is relatively large. When the chlorine is in large excess *only* hydrochloric acid is formed. The experiments appear to have been made at ordinary temperatures.

Ordinary Meeting, December 24th, 1889.

Mr. HARRY GRIMSHAW, F.C.S., in the Chair.

Being Christmas Eve, the attendance was small, and, the usual formal business having been despatched and no paper being presented, the meeting was closed.

A Bibliography relating to the Viscosity of Liquids.
By W. W. Haldane Gee, B.Sc., F.C.S.

(*Received December 5th, 1889.*)

This Bibliography includes chiefly those papers which have been published that relate to:—

(1) The methods proposed for determining the Coefficient of Viscosity of Liquids.

(2) The experimental results obtained.

(3) The relation between Viscosity and Chemical Constitution.

(4) The relation between Viscosity and Electrical Resistance.

Purely Hydrodynamical papers have not been included, unless bearing directly upon Viscosity.

In preparing this list the libraries of the Manchester Literary and Philosophical Society, the Owens College, and the Manchester Corporation (Free Reference Library, King Street) have principally been consulted. As a rule the original papers have been directly consulted.* The arrangement is approximately in chronological order. The number of the volume is given in Roman numerals, and the series within brackets, thus :—(2). The following abbreviations have been used :—

PUBLICATION.	ABBREVIATION.
Poggendorff's Annalen der Physik und Chemie ...	...*Pogg. Ann.*
Wiedemann's ,, ,, ,, ...	...*Wied. Ann.*
Carl's Repertorium der Experimental-physik ...	...*Carl. Rep.*
Berichte der deutschen chemischen Gesellschaft ...	...*Chem. Ber.*

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* I have been unable to directly refer to *Il nuovo Cimento* and the *Journal de Physique.*

PUBLICATION.	ABBREVIATION.
Journal de Physique théor. et appl. publ. par d'Almeida	*J. de Phys.*
Sitzungsberichte der kaiserlichen Akademie der Wissenschaften zu Wien Math. Natw. Classe	*Wien. Ber.*
Philosophical Transactions of the Royal Society of London	*Phil. Trans.*
,, ,, ,, ,, Edinburgh	*Phil. Trans.* (*Ed.*)
Proceedings of the Royal Society of London	*Proc. Roy. Soc.*
Journal of the Chemical Society of London	*J. Chem. Soc.*
Chemical News, edited by Crookes	*Chem. News.*
The Philosophical Magazine and Journal of Science	*Phil. Mag.*
Annales de Chimie et de Physique	*Ann. Chim. Phys.*
Comptes rendus de l'Académie des Sciences	*C. R.*
Die Fortschritte der Physik (Berlin)	*Fort.*
Archives Néerlandaises des Sciences Exactes et Naturelles publiées par la Société Hollandaise des Sciences à Harlem	*Archiv. Néer.*
Bulletin de la Société Chimique de Paris	*Bull. Chim.*
Il nuovo Cimento, Giornale di fisica, di chimica, etc,	*Cim.*
Bulletin de l'Académie Royale des Sciences des Lettres et des Beaux-Arts de Belgique	*Bull. Acad. Belg.*
Polytechnisches Centralblatt (Leipzig)	*Polyt. C. Bl.*
Zeitschrift für Mathematik und Physik (Leipzig)	*Z. S. f. Math.*
Reports of the British Association for the Advancement of Science	*Rep. B. A.*

1800—1820.

Expériences destinées à déterminer la cohérence des fluides et les lois de leur résistance dans les mouvements très-lents.
Coulomb.
Mem. de l'Institut, Math. et Phys. III., p. 246, 1800.

Versuche über die Flüssigkeit des Wassers bei verschiedenen Temperaturen.
Gerstner.
Gilbert's Annalen. V., p. 160, 1800.

Mémoire sur le mouvement des fluides dans les tubes capillaires et l'influence de la température sur ce mouvement.
Girard.
Mém. de l'Institut, Mat. et Phys. p. 249. 1813, 1814, and 1815.

Mémoire sur l'écoulement linéaire de diverses substances liquides par des tubes capillaires de verre.
Girard.
Mem. de l'Acad. des Sciences de l'Institut. I., p. 187. 1816.

Mémoire sur l'écoulement de l'éther et de quelques autres fluides par des tubes capillaires de verre.
Girard.
Mem. de l'Acad. des Sciences de l'Institut. I., p. 260. 1816.

1821—1840.

Ueber die Bewegung des Wassers in engen Cylindrischen Röhren.
G. Hagen.
Pogg. Ann. XLVI. p. 423. 1839.

1841—1850.

Recherches expérimentales sur le mouvement des liquides dans les tubes de très-petits diamètres.
Dr. Poiseuille.
Ann. Chim. Phys. (3). VII. p. 50. 1843.

Ueber den Ausfluss der tropfbaren Flüssigkeiten durch kleine Oeffnungen im Boden der Gefässe.
Vater Parrot.
Pogg. Ann. LXVI. p. 389. 1845.

Einige Bemerkungen über Coulomb's Verfahren die Cohäsion der Flüssigkeiten zu bestimmen.
A. Moritz.
Pogg. Ann. LXX. p. 74. 1847.

Ueber die Bewegung der Flüssigkeiten.
G. Magnus.
Pogg. Ann. LXXX. p. 3. 1850.
Phil. Mag. (4). I., p. 1. 1851.

1851—1860.

Vergleichende Versuche über den Ausfluss des Wassers, Quecksilbers, und Oeles.
J. Weissbach.
Polyt. C. Bl. p. 385. 1851.
Abstract: *Fort.* VI. & VII. p. 187. 1850—1.

Ueber den Einfluss der Temperatur auf die Bewegung des Wassers in Röhren.
Hagen.
Wien. Ber. p. 17. 1854. II.

Neue Versuche über die Bewegung des Wassers in Röhrenleitungen bei kleinen Druckhöhen.
G. Zeuner.
Polyt. C. Bl. p. 136, 1854.
Abstract: *Fort.* X. p. 166. 1854.

Mémoire sur le mouvement de l'eau dans les tuyaux.
H. Davey.
C.-R. XXXVIII. p. 407 & p. 1109. 1854.

Vom Widerstande der Flüssigkeiten gegen die Bewegung fester Körper.
R. Hoppe.
Pogg. Ann. XCIII. p. 321. 1854.

Hydraulische Untersuchungen.
G. Magnus.
Pogg. Ann. XCV. p. 1. 1855.
Phil. Mag. (4). XI. p. 89 & p. 178. 1856.

Nouvelle théorie de l'écoulement des liquides.
Dejean.
C.-R. XL., p. 467. 1855.

Sur les équations différentielles du mouvement des fluides en tenant compte de la température.
Destocquois.
C.-R. XLI. p. 96. 1855.

Ueber die Bewegung der Flüssigkeiten im Kreise der geschlossenen galvanischen Säulen und ihre Beziehungen zur Elektrolyse.
G. Wiedemann.
Pogg. Ann. XCIX. p. 177 (especially p. 221). 1856.

Report of experiments on the friction of discs revolving in water.
J. Thomson.
Proc. Roy. Soc. VII. p. 809. 1856.
Phil. Mag. (4). XI. p. 474. 1856.

Mémoire sur le mouvement des liquides.
Magnus.
Ann. Chim. Phys. (3). XLVI. p. 234. 1856.

Ueber den vollen Ausfluss des Wassers aus Röhren beim Durchgang durch Verengungen und den bei dem plötzlichen Ueberspringen zu dem grössern Querschnitt stattfindenden Arbeitsverlust.

C. T. Meyer.

Z. S. f. Math. I. p. 275. 1856.

Ueber die Bestimmung der Zähigkeit einer Flüssigkeit durch den Ausfluss aus Röhren.

Hagenbach.

Pogg. Ann. CIX. p. 385. 1860.

Über Reibung tropfbarer Flüssigkeiten.

H. Helmholtz und G. V. Piotrowski.

Wien. Ber. XL. p. 607. 1860.

Mémoire sur le mouvement de l'eau à travers les terrains perméables.

Dupuit.

C.-R. XLV. p. 92. 1857.

Recherches expérimentales rélatives au mouvement de l'eau dans les tuyaux.

H. Darcy.

Mém. d. Sav. étr. XV. p. 141.
Berl. Ber. p. 168. 1854.

On the theory of internal resistance and internal friction in fluids and on the theories of sound and of auscultation.

R. Moon.

Proc. Roy. Soc. IX. p. 323. 1859.
Phil. Mag. (4). XVI. p. 528. 1858.

Hydraulische Untersuchungen. Zweiter Theil.

G. Magnus.

Pogg. Ann. CVI. p. 1. 1859.
Phil. Mag. (4). XVIII. p. 161. 1859.

Neue Versuche über den Ausfluss des Wassers unter sehr hohem Druck.

J. Weisbach

Polyt. C. Bl. p. 505. 1859.

De mutua duorum fluidorum frictione.

O. E. Meyer.

Diss. inaug. Regimonte Prussorum. 1860. p. 1.

1861—1870.

On the Capillary Transpiration of Liquids in relation to Chemical Composition.

T. Graham.

Phil. Trans. CLI. p. 373. 1861.

Ueber die Reibung der Flüssigkeiten.

Oskar Emil Meyer aus Varel a. d. Jahde.

Pogg. Ann. CXIII. p. 55, p. 193, and p. 383. 1861.
See also *Crelle J.* LXII. p. 201.

Sur le mouvement des liquides dans les tubes de très-petit diamètre.

É. Mathieu.

C.-R. LVII. p. 320. 1863.

Ecoulement des liquides.

Destocquois.

Mondes. VI. p. 557.

Ueber die Bewegung in widerstehenden Medium.

O. Schieck.

Pogg. Ann. CXXVII. p. 524. 1866.

Théorie des expériences de M. Poiseuille sur l'écoulement des liquides dans les tubes capillaires.

Boussinesq.

C.-R. LXV. p. 46. 1867.

Mémoire sur l'influence des frottements dans les mouvements réguliers des fluides.

Boussinesq.

Liouville. (2). XIII. p. 377.

Note sur le mouvement des liquides.

Destocquois.

C.-R. LXVIII. p. 1207. 1869.

Note on the resistance of fluids.

J. P. Joule.

Proc. Man. Lit. and Phil. Soc. VII. p. 223. 1868.

Note on a theorem of the resistance of fluids.

Walton.

Qu. J. of Math. X. 38, p. 122.

On the hydraulic Buffer and experiments on the efflux of fluids through small openings with great velocity.

Engineer. Oct. p. 257. 1869.

Essai sur la théorie de l'écoulement d'un liquide par un orifice en mince paroi.
J. Boussinesq.
C.-R. LXX. p. 33, 117, and 1279. 1870.

On some difficulties in the received view of fluid friction.
W. Froude.
Rep. B. A. 1869.

Sur la viscosité superficielle des lames de solution de saponine.
G. Van der Mensbrugghe.
Bull. Acad. Belg. (2). XXIX. p. 1.

Sur un principe de statique moléculaire avancé par M. Lüdtge.
G. Van der Mensbrugghe.
Bull. Acad. Belg. (2). XXX. p. 322.
Rapport de M. Plateau ,, ,, ,, ,, ,, p. 286.

Notes of some experiments on the rate of flow of blood and some other liquids through tubes of narrow diameter.
J. M. Duncan & A. Gamgee.
Proc. Roy. Soc. Ed. VII. p. 193. 1869-70.

Ueber Transpiration homologer Flüssigkeiten.
Rellstab.
Inaug. Diss. Bonn. 1868.

Untersuchungen über die Bewegung von Flüssigkeiten in Capillarröhren.
Schlei.
Inaug. Diss. Rostock. 1869.

Ueber den Ausfluss des Quecksilbers aus gläsernen Capillarröhren.
E. Warburg.
Pogg. Ann. CXL. p. 367. 1870.

1871—1877.

On the uniform flow of a liquid.
H. Moseley.
Phil. Mag. (4). XLI. p. 394. 1871.

On the steady flow of a liquid.
H. Moseley.
Phil. Mag. (4). XLII. pp. 184 and 349. 1871.

Ueber den Widerstand, welchen Kugeln verschiedenen Durchmessers und specifischen Gewichts in geschlossenen Röhren finden, welche mit verschiedenen Flüssigkeiten und Lösungen gefüllt sind.

C. Zuschlag.

Dissert. Marburg. 1871.

Sur la résistance des liquides.

Perrigault.

Mondes. (2). XXIII. p. 440.
Abstract: *Fort.* XXVI. p. 117. 1874.

Appareil pour l'étude de l'écoulement des fluides.

B. Eli.

Journal de Physique. (2). I. p. 459. 1872.

Variation du coefficient de viscosité avec la vitesse.

B. Eli.

Journal de Physique. (2). I. p. 224. 1872.

Sul principio della viscosita superficiale dei liquidi stabilito.

J. Plateau.

Cim. (2). V. and VI. 1872.

Réponse aux objections de Marongoni contre le principe de la viscosité superficielle des liquides.

J. Plateau.

Bull. de Belg. (2). XXXIV. p. 404. 1872.

Du Mouvement ascensionel spontané des liquides dans les tubes capillaires.

C. Décharme.

C.-R. LXXIV. pp. 936 and 1300. 1872.
Ann. Chim. Phys. (4). XXVII. p. 228. 1872.

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General Meeting, January 7th, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

Mr. MICHAEL G. GLAZEBROOK, M.A., Mr. F. HARRISON, B.A., and Mr. H. L. JOSELAND, B.A., all of the Manchester Grammar School, were elected Ordinary Members.

Ordinary Meeting, January 7th, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

A discussion on Influenza and Hay Fever took place, in which Dr. HODGKINSON, Mr. GWYTHER, Mr. CHARLES BAILEY, Mr. HEELIS, and others took part. Mr. FARADAY quoted a manuscript letter written by Captain R. Dewhurst, of Halliwell, near Bolton, to Colonel John Leigh Phillips, of Manchester, in 1800 (included in the collection in the possession of the Society), in which Dewhurst stated that many persons had died from influenza in his neighbourhood.

A paper by Mr. H. H. HOWORTH, M.P., entitled "The Author of the Glacial Theory," was read by one of the Secretaries in the unavoidable absence of the author in Portugal. Mr. Howorth maintained that Carl Schimper, the botanist, and not Agassiz, was the real author of the theory.

A discussion followed the reading of the paper, Mr. Heelis urging that the idea of a great ice-sheet was common property long before either Schimper or Agassiz took it up.

The Author of the Glacial Theory. By Henry H. Howorth, M.P., F.S.A.

(*Received December 30th, 1889.*)

At the meeting of the British Association at Newcastle, I ventured in a paper, in which I criticised the extreme Glacial views of Agassiz and his scholars, to speak with some plainness and severity of the way in which the Genevan Professor had appropriated to himself the honour of originating the Glacial Theory, which belonged to another man. For this I was taken to task by Professor Green, who in a homiletic address on the impropriety of unveiling this kind of scientific piracy, unless there was ample evidence to substantiate the charge, seemed unaware of what had been published in Germany and America on the subject.

From the way his remarks were received I gather that there were others in the same state of mind, and, as the question has not been ventilated in England, I venture to bring it before the Society. It is of interest not merely as throwing light on the genesis of a very important and popular hypothesis, but as illustrating, by a critical example, the pernicious habit of appropriating other men's work, which I hold it to be our especial duty to denounce, when it is done by big men who fill a large place in the eyes of the unscientific crowd.

There have been four generally recognised theories to account for the drift phenomena, namely :—(1), the diluvial theory which was largely originated by De Saussure ; (2), the iceberg theory, which, so far as I know, was originated by Wrede ; (3), the glacial theory, which was, if not originated, developed and proved by Charpentier ; and, lastly, the ice sheet theory in its various forms, which is attributed in nearly every text-book known to me to Agassiz. It is this last theory alone which I refer to.

Before Agassiz wrote a line on the subject or had even turned his attention to it, it had been propounded by two scientific men in Germany, apparently working separately, namely, Bernhardi and Schimper. It was the latter of these to whom Agassiz owed his knowledge of it, and to whom my remarks at Newcastle applied. The facts were published in the *Allgemeine Zeitung* for February the 17th and 18th, 1887, where I have read them, and were made the subject-matter of an article by Mr. G. P. Evans, in the *North American Review*, vol. CXLV., pp. 94-97. Carl Schimper, a botanist, and known as an authority upon mosses, was born at Mannheim on February 15th, 1803. He was a precocious boy, and at Munich became the favourite pupil of Schelling. In his various rambles in Bavaria he had been attracted, as many others have been, by the mysterious boulders scattered over the country, which were a double subject of interest to him since they were covered by lichens and mosses which were strange to him. According to the testimony of Dr. Gustav Bezold, he gave a series of lectures in the winter of 1835–36 at Munich to a society of old friends there, including Schinzlein, afterwards professor at Erlangen, Meyer the poet, Döbner, afterwards professor at Aschaffenburg, etc., etc. Of these lectures Dr. Bezold took notes. In them Schimper distinctly urged that the blocks found in the Isar and Würm valleys and on the Starnberg, "foundlings" he called them, had been transported thither not by rivers or water floods, but by ice, and he invoked a long period of cold during which the erratics were distributed.

In July, 1836, Schimper took part in a gathering of Swiss naturalists at Solothurm, when he met Charpentier and Hugi, who had both written about the Swiss glaciers. Agassiz was also there, but he was busy with his work entitled "Poissons, Echinodermes, et Mollusques fossiles," and had merely gone to see Charpentier's collections. Schimper stayed at Bex with Charpentier from September to December, 1836. Agassiz, who was there also, was busy with his shells, and although he listened to the discussions of the two friends, he only once accompanied them on a glacier exploration to the Col de Balme and the Trient Glaciers, which was conducted by Schimper. During this time Schimper pressed upon Charpentier the fact that the ice action to which he had appealed was in no sense a *res domestica*, and limited in its operations to Switzerland, but was, in fact, a widespread effect of a mantle of ice covering a much wider area. On the 19th of December, 1836, Schimper discovered the famous glacier marks in the chalk of the Jura, near Landeron. This fact he communicated to Agassiz, whose imagination was at length fired by the impulsive and picturesque conversations of his friend, and he determined *for the first time to appear in the character of a geologist*, and advertised a course of lectures to be delivered to his fellow-citizens of Neuchatel which were duly announced in the *Courrier Neuchâtelois* of January 24th, 1837. In order to carry out his purpose more effectually he asked Schimper to lend him the notes of the lectures the latter had given at Munich the winter before. As these were locked up, Schimper wrote to his friend and pupil Bezold to forward him his own notes.

These were duly sent. Schimper acknowledged their receipt in a letter dated the 5th of February, 1837, in which were enclosed some verses on the lake of Neuchatel. In this letter he again urged that the granite blocks had not been transported by rivers, but by glaciers before the upheaval of the Alps and the Bavarian mountains, and that, in the penultimate geological period, masses of ice several thousand feet thick covered, not only Switzerland, but all Europe; and that the then existing lakes were also filled with ice, whence it was that the same lakes were not afterwards filled up with alluvion and drift. He goes on to urge that the great blocks must have originally been scattered on the ice, and been carried along by it according to the physical laws which we know govern ice, and that they were thus carried over lakes, valleys, and mountains, and deposited on the high ridges bounding them, etc., etc.

The lectures above referred to proceeded the next month, but in the very first one Agassiz's knowledge of physics, especially of the physics of ice, at this time, proved so slight, that Schimper offered to help him in the subsequent ones; which offer was gladly accepted. Schimper, to commemorate Galileo's birthday, issued a poem on the 15th of February, 1837, entitled "Die Eiszeit: Für Freunde gedruckt am Geburtstage Galilei, 1837." It was signed Dr. K. F. Schimper, Neuchatel, February 15th, 1837, and was distributed by Agassiz among his auditors. This is the first time the term "Ice Age" occurs, and Dr. Volger dates the birth of the glacial theory from its publication; so does Charpentier (see *Essai sur les Glaciers*, 228).

In July, 1837, the Helvetic Society of Natural Sciences met at Neuchatel, and Agassiz addressed to it his famous "Discours préliminaire," which is said to have startled his hearers, and which has been generally accepted as the first public pronouncement on the subject of the glacial theory. In view of this meeting, Schimper, who was then at Carlsruhe, wrote Agassiz a letter, in which he asked "his brother Agassiz" to bring, in his stead, before the meeting this vast and important truth more quickly to the notice of the learned world. In the letter he complains naively how his discovery had already brought him some troubles, since it had aroused the inveterate prejudices of the "desicating-water" and the "cooling-fire" men, and ran counter to the traditional notion of a merely mechanically progressive diminution of the earth's temperature (*id.* 5, see also "Actes de la Société

Helvétique," 1837–38, etc.), and he concludes that the polished surfaces in the Jura, and the erratic blocks, are the result of the action of a great field of ice, "Ein grosses Eisfeld" (*id.* 46). He extended his researches elsewhere than to the Jura, and tells us erratic blocks are scarce in the Black Forest, but he had found some of them, in 1826, near Lake Tili, above Höllenthal, and he had also found them about Carrigou, in the Pyrenees, in 1825 (*id.* 49 and 50).

This letter clearly shows who was the originator and who the mere disseminator of the new views. Agassiz himself, in his address, speaks of his theory as a fusion of his own views with those of Schimper, and refers to an unpublished memoir by his friend. Even this scanty acknowledgment, however, was itself very shortlived, and when Schimper wrote to complain that the press were attributing to Agassiz what had been the work of his own hands, he replied that he did not read the newspapers, and was not aware of their contents, but that the printed report of the society's proceedings would put everything right. When Agassiz published his well known "Etudes sur les glaciers," in 1840, it will hardly be credited that he did not even refer to his friend, and the process of ignoring him, in spite of protests, he carried out to the end.

Braun was a friend both of Agassiz and Schimper, and cognisant of the facts. He was too timid to interfere, however, although a letter is extant which he wrote to Professor Röper, at Rostock, dated February 22nd, 1840, in which he says, speaking of Schimper, "Agassiz und Charpentier, die in dieser Sache jetzt das Meiste thun, sind, wenigstens was die allgemeine Ausdehnung der Ansichten und die tieferen physiologischen Gedanken dabei betrifft, seine Schüler." Agassiz himself, in a letter to Braun, accompanying a copy of the work last cited, and subsequentiy included in Braun's "Life," published by his daughter, writes the following extraordinary sentence :—"Du darfst Dich nicht wundern, den Namen von Schimper darin nirgends genannt zu finden. Ich wollte so seine Anmassung strafen. Alles, was er hätte sein nennen können, wenn auch nur von ferne, habe ich unberührt gelassen, selbst wenn ich beistimmen müsste." Mr. Evans says of this, "wherein consisted this presumption" which Agassiz wished to punish by a policy of utterly ignoring the achievements of a colleague, in a manner which, in the interests of true learning and to the honour of human nature, one would gladly think is rare in the annals of scientific research? Merely in the modest expression of a desire to have his name publicly mentioned in connection with a theory, of which, as is now clearly shown, he was the real and only author." (Evans, *op. cit.* 96 and 97). Well may Mr. Evans say, "Whatever glory emanated from the new doctrine haloed round the brow of Agassiz as its public expounder, and naturally enough he soon grew fond of the easily-won fame. The nimbus of the Saint is a covetable head-gear, provided one is not compelled to win it by the thorny crown of martyrdom." (*North American Review*, CXLV. 96).

The result has been what ought to be expected. Schimper's name has dropped out of geological literature altogether, and is not even referred to in such works as Professor James Geikie's "Ice Age" and "Prehistoric Europe," whose main thesis is that first maintained by the German botanist.

I think I have amply justified the strictures I passed upon Agassiz at Newcastle, which were so unwelcome to Professor Green.

I cannot conclude this paper, however, without some remarks about the ice cap theory of Agassiz, which, according to the President of the Geological Section of the British Association at Newcastle, is repudiated by nearly every geologist. I was not alone in feeling surprise at this statement. That theory has done yeoman's service in recent works on the geographical distribution of animals and plants, and, if it be a fantastic dream, it seems curious that we may search the works of the great prophets of the glacial theory in vain for any definite repudiation of it. One would suppose, for instance, that in the two monographs by Mr. Geikie above-named, both of them published after Agassiz's famous journey to Brazil, there would be found something to warn students who may have need of the glacial theory for their own work, that Agassiz's views about the glaciation of the valley of the Amazon are preposterous. Nor can I find a sentence in which Agassiz's views are impugned by name at all. If, then, there has been a general rejection of his later views by those professedly his scholars, where is it to be found? They assuredly owe it to his memory and to the world of science, to make it quite clear how far they go with him, and whether they have anything but *a priori* grounds for repudiating the positive statements made by Agassiz, by Hartt, and by Belt, who all visited the tropical regions of America, and who were all trained geologists, that the facts they saw in the valley of the Amazon and in Nicaragua, and which included roches moutonnées, erratics, and other drift phenomena, were not the débris of ordinary subaerial denudation, as Professor James Geikie urged at Newcastle, but precisely similar to the drift phenomena of North America and Europe, and merely proved the extension of the ice sheets from the 46th parallel to the equator. For people who hold my views, Agassiz's later theories, like his earlier ones, are as valuable as most transcendental works in science; but for believers in ice sheets, themselves the scholars of Agassiz, it is a very different matter.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, January 13th, 1890.

Mr. J. COSMO MELVILL, M.A., F.L.S., President of the Section, in the Chair.

Mr. CAMERON exhibited a new species of parasite on the Ant, from South Africa, which he proposed to describe more fully later.

Mr. THOMAS ROGERS showed the flower of the *Aspidistra lurida.*

Mr. CHARLES BAILEY, F.L.S., put under the microscopes, cystoliths, water-glands, pricking hairs, glandular capitate hairs, and stinging hairs, as illustrating heteromorphism in the epidermal appendages of nettles.

General Meeting, January 21st, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R S., President, in the Chair.

Mr. JAMES NASMYTH SIDEBOTHAM, of Altrincham, and Mr. HOWARD C. SACRÉ, of Higher Broughton, Manchester, were elected ordinary members.

Ordinary Meeting, January 21st, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., President, in the Chair.

Reference was made to recent correspondence in the Manchester papers respecting the Society's former member, William Sturgeon, the electrician, and it was stated that the Society's collections included certain relics of Sturgeon's work.

Mr. FARADAY read two unpublished letters written by James Anderson, LL.D., the Scotch agriculturist and economist, who, in 1777, in a tract entitled, "An Inquiry into the Nature of the Corn Laws," completely stated the theory of rent subsequently known as Ricardo's. The letters were addressed to Colonel John Leigh Philips, of Mayfield, Manchester, and were dated from Leith, December 24th, 1794, and July 24th, 1795, respectively. A statement in one of the letters to the effect that the writer had no hesitation in saying that a bridge might be constructed of cast iron with a single span of 500 feet and without the use of "a single ounce of wrought iron," was referred to by the PRESIDENT as a remarkable statement considering the date, and a conversation on iron bridges ensued.

Professor W. C. WILLIAMSON communicated a paper by Mr. A. C. Seward, M.A., F.G.S., on "*Sphenophyllum* as a branch of *Asterophyllites*." It was pointed out during the discussion that the paper confirmed the conclusion long since arrived at by Dr. Williamson, that the separation of *Sphenophyllum* from *Asterophyllites* is not scientifically justifiable.

Sphenophyllum as a branch of Asterophyllites. By A. C. Seward, M.A., F.G.S., St. John's Coll., Cambridge. Communicated by W. C. Williamson, LL.D., F.R.S.

(*Received January 21st, 1890.*)

In the *Verhandlungen der K. k. Geolog. Reichsanstalt* (No. 15, p. 329), Herr Stur, of Vienna, published a short notice in which he described a specimen shewing *Sphenophyllum* to be a branch of *Asterophyllites*. He maintained that *Sphenophyllum* should not be regarded as a distinct genus, but rather as the macrospore-bearing branch of *Asterophyllites*, both genera being branches of true *Calamites*. In the volume on the "Flora of the Schatzlarer Schichten[1]" published in 1887, figures are given by Stur of the specimens on which he based his conclusions as to the relationship of the two genera *Asterophyllites* and *Sphenophyllum*. A short time since, in looking through the Fossil plants in the Munich University Museum, I was fortunate enough to find a specimen which appears to afford strong additional evidence in support of Stur's conclusions. On the question of the connection between the two genera *Asterophyllites* and *Sphenophyllum* with *Calamites* this specimen throws no light. The genus *Sphenophyllum* established by Brongniart, in 1822, under the name *Sphenophyllites* is defined by him in the "Tableau des genres de végétaux fossiles[2]" as follows :—" Feuilles verticillées, cunéiformes, tronquées, entières ou dentées, émarginées ou profondément dichotomes, quadrilobées à lobes plus ou moins profonds et grêles."

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[1] Die Carbon-Flora der Schatzlarer Schichten. Von D. Stur. Taf. xi. and xv. Wien 1887.

[2] Tableau des genres de vég. fossiles. p 52.

In 1864 Coemans and Kickx published a monograph[1] on this genus, and their definition, like Brongniart's, makes the wedge-shaped form of the leaves and the absence of a median nerve essential characters. Every observer recognises the great diversity of form which exists in *Sphenophyllum* leaves, but whether *Asterophyllites* may be considered an extreme case of this variation in leaf-form is a matter of dispute. Prof. Williamson has more than once expressed his belief that *Asterophyllites* and *Sphenophyllum* cannot be regarded as distinct genera. He says[2]: "*Asterophyllites* and *Sphenophyllum* are genera so closely allied that their separate existence finds but little justification in nature." Professors Solms-Laubach, Renault, and others maintain that these two genera are clearly defined and cannot but be considered as distinct. Prof. Weiss,[3] without going so far as Carruthers and Stur in regarding *Asterophyllites* and *Sphenophyllum* as branches of *Calamites*, admits that it is impossible to attach any great importance to the difference in leaf-form as a means of distinction between these two genera.

The figures given by Schenk[4] and Germar[5] (reproduced in *Figs.* 2 and 3) shew better than any I know the association of the wedge-shaped type of *Sphenophyllum* leaves with others much narrower and more deeply dissected. That in these cases we have true Asterophyllitean leaves, that is linear leaves provided with a mid-rib, cannot be definitely asserted ; even the most finely-divided leaves appear to be

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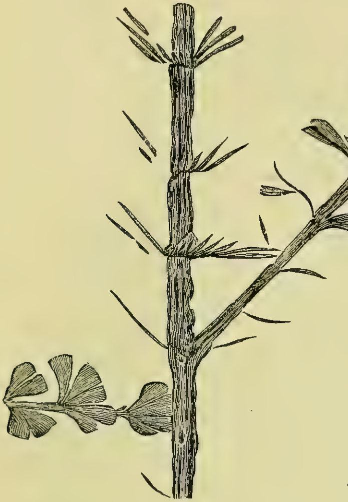
[1] Monographie des Sphenophyllum d'Europe ; par MM. Coemans et Kickx. *Bull. de l'Acad. Royale de Belgique.* 33$^{\text{me}}$ année, 2$^{\text{me}}$ sér. Tab. xviii. p. 134. (1864).

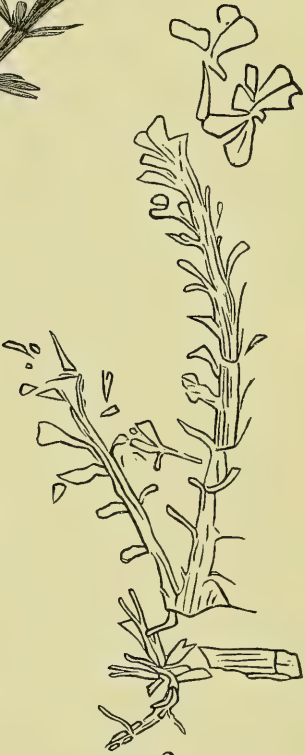
[2] On the organisation of the Fossil plants of the Coal-Measures. Pt. IX. *Phil. Trans. Royal Society.* Pt. II. 1878, p. 334.

[3] *Neues Jahrbuch für Mineralogie, Geologie und Palæontologie.* 1879, p. 262.

[4] Richthofen. China, Bd. IV. Pflanzl. Versteinerungen v. Schenk. Taf. xliv., *Fig.* 1.

[5] Die Versteinerungen des Steinkohlengebirges von Wettin und Löbejün im Saalkreise. Taf. VI., *Fig.* 3.





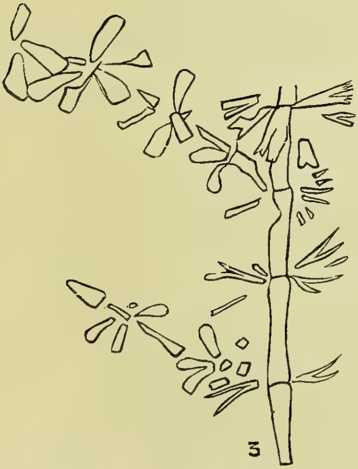


Fig. 1.—Original in the Palæontological Museum, Munich.

Fig. 2.—Copy of a portion of *Fig.* I., Pl. XLIV. Richthofen's "China."

Fig. 3.—Copy of a portion of *Fig.* 3, Pl. VI.—"Die Versteinerungen des Steinkohlengebirges von Wettin und Löbejün."—Germar.

branches of deeply dissected forms such as *Sphenophyllum saxifragæfolium* or *S. myriophyllum.* In Stur's admirable figures, the accuracy of which I can vouch for, having had an opportunity of seeing the original specimens, the verticils of leaves on the Asterophyllitean branches are either absent or at best badly preserved, but where they do occur they have the appearance of true Asterophyllitean leaves. Such leaves are best seen on the third internode from the bottom of branch G. *Fig.* 5. Taf. XV.

The specimen before us (*Fig.* 1), although much smaller than those in the Vienna museum, shews still more clearly than they the association of Sphenophylloid and Asterophyllitean leaves. On the Asterophyllitean branch there are six internodes and five on the Sphenophylloid branch—length of main branch 8·7 cm., small branch 5·5 cm. ; on the third node there are portions of twelve leaves all of which are single. The form of the Sphenophylloid leaves is best seen in the case of those at the summit of the branch ; those on the lower nodes lie at an angle to the matrix of the rock and are only partially seen. There is not the least doubt as to the attachment of the two branches ; on the left side of the main one is a broken piece of another *Sphenophyllum* branch. The side branch may possibly have borne a Volkmannia strobilus, as do those figured by Stur. The specimen (*Fig.* 1) is from Waldenburg, in Silesia ; the geological horizon is not mentioned on the label.

In cases where the upper part of *Sphenophyllum* stems have broad cuneiform leaves of the type *Sphenophyllum Schlotheimii*, &c., and more finely-divided leaves occur on the lower part, the form of the latter kind is considered by many as a morphological variety due to submersion of the lower part of the plant. In the case of Stur's specimens and the one here figured this variation in leaf-form can hardly be explained by such a hypothesis. Schimper[1] considers that the absence of intercellular spaces in the stem of *Sphenophyllum* negatives the usual explanation that the finely-dissected leaf-form is the result of modification brought about by submersion. Whatever be the cause of such difference in the form of the leaves, may we not regard the Sphenophylloid leaves as having been formed by a coalescence of groups of acicular Asterophyllitean leaves? Germar's figure (*Fig.* 3) affords us a good example of a case where the passage from cuneiform to linear leaves may be traced. As Prof. Williamson[1] has remarked, this explanation of the formation of the broad leaves by coalescence of linear ones accounts for the smaller number of the former in each verticil compared to the larger number of the latter.

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[1] Handbuch der Palæontologie. II. Band, ii. Lieferung, p. 178.

The evidence for the close connection between stems having these two types of leaves does not rest merely on specimens which show no internal structure. In Memoir V. of the *Phil. Trans.* Prof. Williamson has described a series of specimens shewing different stages in the growth of an Asterophyllitean stem; the stems from which the sections were taken were found with Asterophyllitean leaves attached to their nodes.

In Plate III.[2] (*Figs.* 14—17) sections are figured where we have a verticil of acicular leaves, sections of which shew a single vascular bundle in each case: in Memoir IX.[3] there is another section described and figured, where we have not only traces of leaves, but in the cortex of the stem are a number of vacant spaces, which were no doubt originally occupied by foliar bundles. Prof. Williamson points out the resemblance between the structures described by himself in these Asterophyllitean stems and those described by Renault in *Sphenophyllum* stems: in the one case the stems have undoubted Asterophyllitean leaves, and in the other equally well-defined *Sphenophyllum* leaves. Renault[1] admits the practical identity of the stems, but considers that Williamson's specimens should be referred to *Sphenophyllum* and not to *Asterophyllites.* I have had the privilege of examining the sections of Professors Williamson and Renault, and have convinced myself of the good grounds on which these authors respectively referred their specimens to *Asterophyllites* and *Sphenophyllum.*

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[1] *Phil. Trans. Royal Society.* 1874. Pt. V., p. 77.

[2] *Phil. Trans. R. S.* 1874.

[3] *Phil. Trans. R. S.* Pt. II. 1878. Plate XXI., *Fig.* 32.

That Calamites possessed branches indistinguishable from *Asterophyllites* has been often asserted. Without, however, venturing to go so far as to accept it as proved that the three genera, *Calamites*, *Asterophyllites*, and *Sphenophyllum*, are in reality one, it seems reasonable, considering the evidence obtained for the connection of *Asterophyllites* and *Calamites* on the one hand and *Asterophyllites* and *Sphenophyllum* on the other, to regard the term *Asterophyllites* as indicating a particular morphological condition rather than a distinct genus. The definition of *Sphenophyllum*, as it now stands, does not include leaf-forms having the Asterophyllitean characters ; if the genus be retained the definition must be altered so as to include not only the wedge-shaped leaves which may be entire, toothed, or more or less deeply lobed, but also forms having a mid-rib and possessing Asterophyllitean characters.

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[1] Cours de Botanique fossile, deuxième année, pp. 91 and 92 (Paris, 1882).

Ordinary Meeting, February 4th, 1890.

EDWARD SCHUNCK, PH.D., F.R.S., F.C.S., Vice-President, in the Chair.

Dr. ALEX. HODGKINSON described a very fine spectrum formed by the light through a doorway in the Blackpool Aquarium falling on the corner of one of the tanks, the rain band being distinctly visible.

Mr. FRANCIS NICHOLSON, F.Z.S., alluded to the exceptional abundance of jack-snipes during the season, and a discussion on the relative increase or decrease of different species of birds in the vicinity of Manchester ensued. Dr. SCHUNCK mentioned that he had observed that sparrows in the neighbourhood of his residence at Kersal appeared to have a special preference for the stigma of the yellow crocus. Mr. CHARLES BAILEY suggested that the attraction was probably the greater abundance of nectar, the stigma and other parts of the flower being destroyed merely in the process of getting at the nectar.

Mr. R. F. GWYTHER, M.A., read the following obituary notice of the Society's late honorary member, M. Gustave-Adolphe Hirn, of Logelbach, near Colmar, Alsace :—

"The death of Gustave-Adolphe Hirn, which occurred at Colmar on the 14th of January, has followed quickly upon that of Dr. Joule, and little more than a year after that of Clausius. Hirn was born at Logelbach, near Colmar, on the 21st of August, 1815, and entered the print-works of some relatives at Logelbach as chemist. When, later, this industry was changed for that of weaving, he retained the scientific direction of the works. Though this was the only English Society of which he was an honorary member, he was member or associate of most of the learned

Societies on the Continent and in America, as well as corresponding member of the Institute of France. In 1880 he founded a meteorological observatory at Colmar, and wrote several papers on the meteorology of the Rhine Valley.

"His business as manager of works not only brought directly under his notice practical questions of economical transmission of power and of the mode of action of lubricants, but also placed at his disposal machinery for making experiments on a large scale, of which he took advantage with great industry and exceptional skill. Hirn's publications have been numerous and very diverse both in manner and method, dealing both with experiment and with theoretical conclusions. Besides his important Treatise on the Mechanical Theory of Heat, I may mention the memoirs on Thermodynamics, on the theory of the gyroscope, on the conditions of equilibrium and probable nature of Saturn's Rings, on the optical properties of flame and the temperature of the sun, and a popular discussion of the conditions of life on Saturn, as well as a work on the philosophical and metaphysical consequences of Thermodynamics. Hirn not only maintained very strongly his opinions on the sciences which he studied, but he also expresses his views on more general matters when they arise in connection with the subject under consideration.

" He protests against the common practice of stating a metaphysical proposition, and claiming that it is proved by some physical experiments ; especially against representing that, in proving the falsity of the doctrine of imponderables, the modern theory of thermodynamics has placed it beyond doubt that the phenomena of heat, electricity, and magnetism are to be, of necessity, considered as movements of ponderable matter, with deductions that force has no real existence in the Universe, that gravitation is but the consequence of some invisible motion of atoms in space, and so on. Materialist doctrines of this kind he speaks of as monstrous nonsense of which Epicurus and Lucretius would have been ashamed if they had possessed one-tenth part of the exact knowledge available to the metaphysician of the 19th century, and he fears that, just as the old doctrines of imponderables had placed obstacles in the way of scientific progress, so the new materialistic doctrines will in their turn delay the development of new ideas. He was strongly opposed to the popular habit of gauging the merits of a discoverer merely by priority of dates, which he maintains has turned the domain of science into the theatre of a kind of steeplechase, with the result that not only are works published in an immature state without cohesion or pretence of completeness, but that, in consequence, the numbers of those willing to read a well considered and exhaustive memoir on any subject are becoming smaller and smaller. Following Verdet, he considers that the founder of a theory is not the author from whose works a glimmering, more or less vague, of the theory may be extracted, but he who is the first to form a body of scientific doctrine out of what may have previously been a vague hypothesis, and he evidently assigns to Joule the chief merit in founding the mechanical theory of heat. In accordance with the first of these views, and in spite of an obvious bent towards metaphysical reasoning, Hirn insists upon the experimental basis of the mechanical theory of heat, and decries the idea of an *à priori* demonstration as resting upon gratuitous assumptions or upon arguments in a circle. If the principles and facts, to-day so impregnable, are so evidently and naturally consequences of an innate and axiomatic first principle, how is it, he asks, that Rumford's and Davy's work bore no fruit, or that Oersted advised Colding to be prudent and keep his ideas and experiments in his desk or they would bring their author into discredit and ridicule? In the same spirit, Hirn considers the great merit of the founders of the mechanical theory of heat to have consisted not so much in the production of a more correct hypothesis, as in placing themselves above hypotheses, and considering the effects not only as equivalent among themselves, but as the measure of the causes whatever they might be. Just as he considers that the great merit of Newton lay in stating that the celestial motions ensue *as if* the bodies attract each other across space, and in avoiding any explanation, more or less plausible, of the mechanism of this attraction ; adding, that if Newton had presented his equations as the results of a hypothesis of this nature, the mechanical sciences might have been still kept in their cradle.

"M. Hirn's own experiments on the numerical measure of the mechanical equivalent of heat began in 1844, at a time when he was ignorant of Joule's work, and the first publication of his results appeared in the "Bulletin de la Société industrielle de Mulhouse" in 1855. Other results were published in 1857 and in 1858, and a final series of experiments was conducted in 1860 and 1861, to the correctness of which he makes a strong claim. Reviewing his own experiments in 1875, Hirn selects four series as those in which he feels most confidence ; these depend upon hammering lead, the friction of water, the flow of water under great pressure, and drilling iron, and the values of the mechanical equivalent in kilogram metres deduced are 424·5, 432, 433, and 425. Among these he inclines to 432 as giving the value most approximately. Also, from a method dependent upon the expansion of air and the ratio of the specific heats, he concludes that 440 is greater than the possible maximum value. It will be remembered that Joule's determination by different methods varied from 419·5 to 488·3, and that it was only after a very careful consideration that he decided upon 424 as the most satisfactory value. It is evidently with regret that Hirn finds himself obliged to select as his most reliable experiment, one which gives a value at all different from that of 'the great Manchester Physicist.'

"Hirn's work in thermo-dynamics was not limited to the determination of the mechanical equivalent, but extended to the theory of heat engines, and he was, I believe, the first to remark that regenerators (or heat economisers) are without useful effect upon an efficient air engine. He does not deny that they may be economically useful upon any particular engine, but points out that the fact of their producing an economy proves the existence of a grave defect in the engine; and that they can properly be regarded only as a means of raising the efficiency of a defective engine. A very important work of Hirn's was upon superheated vapours, which he undertook in order to elucidate the economical working of engines, and to supply an experimental basis of the Second Law of Thermo-dynamics: and he was the first to notice an abnormal action of ether vapour. Generally, if at the commencement of an operation the vapour is dry and saturated, there is a condensation of the vapour upon expansion, and it becomes superheated on compression, *i.e.*, provided there is no loss or gain of heat; but in the case of ether he found the action to be reversed. This curious result was explained theoretically by Rankine, and has been experimentally verified by M. Cazin, who has shewn that there is a point of inversion for all vapours—that is, a temperature above and below which they act differently. The point of inversion for ether is about $-115°$, while for the vapour of water it is about 520°. The results of Hirn's work in this direction are expressed in what is called Hirn's Law—That the internal work of a superheated vapour is proportional to pv, between the point of condensation and that at which it possesses the property of a permanent gas. So that if a gas neither does external work nor gains nor loses heat, we have pv = constant, and the curve connecting p and v is an equilateral hyperbola. It will be remembered that the temperature will change during the operation, and that this is not a form of Marriotte's Law. Like the usual laws of gases this is doubtless only an approximation to the actual law.

"Before leaving this subject, I would add that Hirn considers that his experiments show that there is a real measurable cohesion in both gases and vapours. This force of cohesion he calls the internal pressure, and considering what we usually call the pressure of a gas as the difference between the intensity of the expansive action of heat and this internal pressure, he is able from his experiments to estimate it. For example, in the case of superheated steam at 15·38 atmospheres and 200°, he finds the internal pressure to be 3 atmospheres. In this way Hirn proposes to explain how it is that while, in accordance with Faraday's Law, a definite electric current will deposit from metallic solutions an amount of metal proportional to the chemical equivalents of these metals, the combination say of 1 gram of oxygen with an element say of iron or zinc does not produce even approximately the same amount of heat as it should do if the act of chemical combination corresponded definitely to an electric separation. By considering chemical affinity and the cause of cohesion as different things, acting independently in any combination, the work done in a chemical action consists of two parts: one in the change of position due to the chemical action, and the other due to the change in the molecular attraction or internal pressure. The heat due to the first is equivalent to the electric action which accompanies the chemical action, the heat due to the other is independent of it, and is comparable with that developed in the compression of a gas or condensation of a vapour. Hirn's views regarding gases and vapours appear to be peculiar to him, and at variance with those generally held. It is a subject upon which the last word has yet to be said. Early last year, Hirn published a work on the Constitution of Celestial Space, in which he enquires into the nature of the medium or agent which establishes and carries on the relationship between the celestial bodies. He concludes that it cannot be matter even in the state of diffuse gas, that space generally is void of matter, and that ponderable matter only exists in distinct forms, as stars in a solid form, and as nebulæ in a state of extreme diffusion."

In the discussion which ensued it was pointed out that Hirn, like Joule, Eaton Hodgkinson, and others was a distinguished example of the not infrequent attainment of great results in science and philosophy by men engaged in commerce and industry as distinct from professional scientific avocations.

[*Microscopical and Natural History Section*].

Ordinary Meeting, February 10th, 1890.

Professor WILLIAMSON, LL.D., F.R.S., Vice-President of the Section, in the Chair.

Dr. ALEX. HODGKINSON explained a method of producing a small vacuous space by pressing the convex surface of a plano-convex lens on to the surface of a plate of glass sunk below mercury. He spoke of its use in enabling him to examine Newton's rings *in vacuo*.

General Meeting, February 18th, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., President, in the Chair.

Mr. THOMAS HARKER, of Manchester, was elected an ordinary member.

Ordinary Meeting, February 18th, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., President, in the Chair.

The PRESIDENT appointed Mr. RALPH HOLMES, B.A., and Mr. FRANCIS JONES, F.R.S.E., Auditors of the Society's accounts for the current session.

A discussion was started on Professsor Hertz's experiments on electric oscillations and their interpretation, and Mr. W. H. JOHNSON spoke of the waste of power in the ordinary methods of producing light. The PRESIDENT expressed his opinion that, except for incidental expenses, lighting by electricity neither need be dearer nor more wasteful than any other mode of lighting. This was combatted by Mr. W. H. JOHNSON and Mr. JULIUS ALLMANN, who instanced the lighting of the Suez Canal by light hydrocarbons as being much cheaper and more effective.

The following obituary notice of the Society's late honorary member, Dr. H. C. Buys Ballot, of Utrecht, Superintendent of the Royal Meteorological Institute of the Netherlands, by Professor ARTHUR SCHUSTER, F.R.S., was read by one of the SECRETARIES in the unavoidable absence of the author :—

"In the first half of this century Meteorology was a purely statistical science. It is now gradually becoming a branch of Hydro-dynamics and Thermo-dynamics. Statistics is still its chief weapon of research, but it is no longer blind statistics led hither and thither by the guesses of the enquirer, for its line of attack is regulated by our knowledge of the laws which determine the motion of a gaseous medium, and of the complicated effects which accompany evaporation and condensation of moisture. The Society has recently lost two of its ordinary members, Balfour Stewart and Baxendell, who have both done much to establish meteorology on the sound basis on which it now rests; and it has now to mourn the loss of an honorary member, who, by common consent, occupied the foremost place amongst the founders of the new science.

"Buys Ballot was born October 20th, 1817, and although he once held a chair of Mathematics and Geology, and published papers on various physical and chemical subjects, he ultimately turned his attention entirely to Meteorology. I am not sufficiently well acquainted with his work to give the Society an adequate idea of all he accomplished, and must confine myself entirely to a short account of what must be considered the chief result of his labours. When Buys Ballot was in the prime of life, the authority of Dove at Berlin was still all-powerful in matters of meteorology. Dove had done much to systematise the science, and to encourage its scientific study. He had found a purely empirical law, which seemed to indicate a regular change in the direction of the wind. A north wind he found was more often succeeded by an east wind than by a west wind, and a south wind was more often succeeded by a west than by an east wind. In other words, the weathercock more often turned in the direction in which the hands of a watch move, than in the opposite direction. This empirical law we now know has some justification in Germany, from which country Dove chiefly derived his observational data; but we also know now, that this is due to the fact, that the cyclones which affect Germany pass chiefly due north of it, in a direction from west to east. Nevertheless, at the time, Dove's law of the rotation of winds seems to have been accepted by meteorologists as a law of nature. To doubt it was heresy.

"Buys Ballot, from a careful consideration of the direction of the wind, observed not in the same spot at different times, but at different spots at the same time, established the laws which have since received ample confirmation. If at any place on the earth there is a barometric depression, the air will circulate round that depression in a direction opposite to that in which the hands of a watch move. There will also be an inward motion, due to friction against the ground, so that each particle of air will describe a spiral towards the barometric minimum. In the centre of the cyclone there will be an ascending current of air, maintained by the condensation of moisture.

"The principal facts established by Buys Ballot had been already deduced, chiefly from theoretical considerations, by an American investigator, Ferrel; but his work remained unknown. Although priority belongs to Ferrel, Buys Ballot had to undertake the difficult task of contending against Dove's authority, and convincing the scientific world. The ability and skill which finally ensured his success, are testified to by the unanimous regard and esteem with which in his later years he was looked upon by all his scientific contemporaries.

"The present form of the weather charts with the drawing of the lines of equal pressure, or isobars, which are now published by the Meteorological office, and which have helped so much to advance our knowledge of atmospheric circulation, is due to another of our honorary members, Buchan of Edinburgh, though Buys Ballot was the first to develop the idea of a graphical representation of the distribution of weather. He drew straight lines in a horizontal direction to indicate that the temperature was below the average, vertical lines were drawn wherever the temperature was above the average, and the shading was so arranged that the greatest deviation from the average was indicated by a stronger line. The region comprised in these charts extended over central Europe."

Examples of Ballot's charts were exhibited, and a discussion on general meteorological questions ensued, special reference being made to the hypothetical relations between atmospheric pressure and coal-mine explosions. Mr. FARADAY mentioned a new theory, started in a London paper, to the effect that explosions are rather coincident with a high than a low barometer, and that the increased atmospheric pressure on the earth forces out the gas. The PRESIDENT held that it is probable that the tendency to explosions in autumn and winter is due to the rising of the underground water rather than to any changes in the barometer, and also that probably there is more work going on then than at other periods of the year. Mr. BROGDEN maintained that the conditions of collieries are so dissimilar that different circumstances have different effects in different collieries, but he thought that all changes of pressure mark the times of danger. The issue of blowers of gas is probably little affected by changes of pressure.

General Meeting, March 4th, 1890.

EDWARD SCHUNCK, PH.D., F.R.S., F.C.S., Vice-President, in the Chair.

Mr. H. A. HENDERSON, of Manchester, was elected an ordinary member.

Ordinary Meeting, March 4th, 1890.

EDWARD SCHUNCK, PH.D., F.R.S., F.C.S., Vice-President, in the Chair.

Mr. SEMMONS (introduced by Dr. Burghardt) exhibited specimens of sandstone of triassic formation from the North of Spain ; the stone contained both the blue and the green carbonate of copper, and apparently remains of plants, one of which had some of the appearances of an *Equisetum*. The interest of the communication lay in the rarity of plant remains in the triassic formation. The impressions had a black appearance, and were found to contain oxide of copper.

Dr. SCHUNCK called attention to Dr. Gerhard Kruss's alleged discovery that commercial nickel contains an admixture of 2 per cent of a foreign substance, from which it must be inferred that the nickel hitherto regarded as a pure metal is an alloy, and that pure nickel resembles more closely silver in appearance. A discussion ensued, in which Mr. C. O'NEILL, Dr. BOTTOMLEY, Mr. C. N. ADAMS, and Dr. BURGHARDT took part. Dr. BURGHARDT stated that his experiments did not lead him to consider nickel as an alloy, and that the unknown mineral would seem to possess chemical properties very similar to those of nickel. He suggested that commercial nickel from New Caledonia did not give the same analysis as nickel from the older sources, and appeared now to be common in the market. In summing up the discussion, Dr. SCHUNCK said that he did not agree with the opinion expressed that it was improbable that such an impurity should have been so long overlooked by chemists.

Dr. BURGHARDT read a paper on "Some applications of Caustic Soda or Potash and Carbon in the qualitative and quantitative Analysis of Minerals," and showed the method practically before the members as applied to tin ore from Cornwall, wolframite or tungstate of iron, and chrome iron ore. The method appeared to be an easy one, only a few minutes being occupied in each experiment, and it seemed to give very complete reactions with satisfactory results.

On some applications of Caustic Soda or Potash and Carbon in the qualitative and quantitative Analysis of Minerals. By Charles A. Burghardt, Ph.D.

(*Received March 4th, 1890.*)

To those chemists who are brought much into contact with minerals and metallic ores, it has been for a long time a desire that the processes by which such minerals are made available for analysis should be rendered short, accurate, and simple. The minerals I refer to, of course, are those which are insoluble in acids. As is only too well known to chemists, a considerable expenditure of time and much patience is often required before the desired splitting up of the mineral and its solution is arrived at. There are, generally speaking, three kinds of fusing-mixtures or fluxes which the chemist has at his disposal (for it is necessary to fuse the refractory mineral at a high temperature for a long time with one or more of these fusing mixtures), the commonest fusing mixture being one consisting of carbonate of sodium and nitrate of potassium, and most minerals can be eventually split up by its action. Some minerals are only acted upon by being fused with hydrogen potassium sulphate, it sometimes being necessary to split up partially with the first-mentioned fusing mixture, the process being finished by fusing the insoluble still refractory residuum with the hydrogen potassium sulphate. With many minerals these reactions are not complete even after several fusions at a long sustained very high temperature. This entails much labour at the blowpipe-table, and annoyance if the results obtained are not satisfactory. I am aware that many methods have been devised for arriving at satisfactory results by modifying, in various ways, the well-known fusion processes, but so far without very much real improvement.

I venture to-night to lay before you a general process which deals with all the refractory silicates, several refractory oxides and compounds of oxides, and some other insoluble mineral compounds. I am still occupied in ascertaining whether this process is applicable in the case of minerals where sulphur, arsenic, and antimony enter largely into their composition, and hope later on to lay the results obtained before this Society. After many experiments I found that the best results were obtained by mixing the finely divided mineral with about ten per cent of its weight of finely divided charcoal, and projecting the mixture carefully into a silver crucible containing fused hot caustic soda or potash, about six times the weight of the mineral powder taken for analysis. The crucible and its contents are then carefully heated over an ordinary Bunsen-burner until the reaction arising has taken place, this point being easily ascertained by the fact that all further evolution of combustible gas has ceased, and the mass remaining in the crucible has become dry, and generally white or grey in colour. From the experiments which I have made I conclude that hydrogen gas is evolved from the caustic alkali, and possibly a small quantity of carbon monoxide, whilst undoubtedly carbon dioxide is largely produced by the combination of the carbon with the oxygen of the caustic alkali and the oxygen of the oxides present in the minerals taken for analysis. Further, there is no doubt in my mind that metallic sodium or potassium is liberated during the course of the reaction, and these metals, whilst in the *status nascendi*, combine either with the metallic oxide (as in the case of oxide of zinc and oxide of tin) or with the acid present in the minerals. The latter conclusion will be more apparent after describing in greater detail the various experiments which I have made.

Quantitative analysis of Tin-ore from Cornwall.

Two samples of roasted so-called black-tin were powdered to an exceedingly fine powder and submitted to the process sketched out above. Black-tin is the technical term applied to tin-ore which has been concentrated by washing away the lighter mineral impurities, drying, and afterwards roasting to free it from sulphur, arsenic, and antimony.

I took 0·5 gram of the sample, mixed it carefully with sufficient powdered charcoal, and added the mixture carefully to the melted hot caustic alkali (soda was used in most cases) in the silver crucible. Heat was then gently applied with an ordinary Bunsen-burner, and the mass heated until no further evolution of burning gas was observed, generally, thirty minutes heating being sufficient. The crucible and its contents were then placed in a porcelain basin, and the contents dissolved out with distilled water, and filtered from the insoluble oxides, undecomposed carbon, &c. I always submitted the residue to a second fusion, and found in most cases that every trace of mineral was completely decomposed after the second fusion. In the solution were silicate of sodium, aluminate of sodium, and stannate of sodium, whilst in the insoluble residue were silica, bismuthic oxide, cupric oxide, ferric oxide, calcium carbonate, and manganese dioxide. The details of the method of analysis of the insoluble residue it will be unnecessary for me to enter into here, whilst the analysis of the soluble portion simply resolved itself into the elimination of the silica from the solution (previously treated with hydrochloric acid in excess) in the usual manner, the precipitation of the tin as sulphide, and its subsequent conversion into stannic oxide, in which form it was weighed.

The analyses resulted as follows, viz. :—

Sample..	No. 1.	No. 2.
Stannic Oxide (SnO_2)	66·04	82·84
Silica	14·80	4·20
Manganese Dioxide	1·90	none
Ferric Oxide	13·60	8·04
Cupric Oxide	2·48	4·20
Calcium Oxide	0·40	none
Bismuthic Oxide	0·08	1·28
	99·30	100·56

I found that 95 per cent of the total tin in the ore was taken up in the first fusion, which I consider a very satisfactory yield. By the old method of analysis the fusion would have to be performed over a blowpipe for an hour or more and repeated at least three times in order to extract all the tin. *For success either by the old process or by my process, an extremely fine state of division of the sample is necessary.*

Quantitative Analysis of Wolframite.

This mineral is practically tungstate of iron. It is a difficult mineral to analyse by the old methods and much time is required to carry out the different processes. By my process the iron is entirely separated from the tungstic acid *at once* and remains behind (after solution of the melt and subsequent filtration) on the filter paper as ferric oxide and magnetic oxide. The greater portion of the manganese present in the mineral is also found on the filter paper as manganese dioxide with the iron. In the solution there is tungstate of sodium, manganate of sodium and silicate of sodium. The tungstic acid is thrown out of this solution (along with any niobic acid which may be present) by adding a slight excess of hydrochloric acid and boiling, when the tungstic acid, WO_3 is precipitated out as a yellow powder, dried, ignited and weighed. Of course if niobic acid is present it must be separated from the tungstic acid.

A specimen of Wolframite on analysis by the new method furnished the following result, viz. :—

WO_3	64·00
FeO	17·51
MnO	11·67
SiO_2	7.20
	100·38

In this analysis I think the error is due to the silica being too high.

Quantitative Analysis of Chrome Iron Ore.

I have not had time to completely analyse the sample operated upon by the new process, but append the results, as below, the silica and alumina being obtained by difference. I varied the general method in this special instance by adding ammonium nitrate to the solid caustic soda *before* introducing the same into the silver crucible. This addition of the ammonium nitrate is to cause the chromic oxide liberated to be at once oxydised to chromic acid and combined with the excess of caustic soda present, thus forming sodium chromate. The method of working is briefly as follows :—

The finely divided levigated sample was mixed with ten per cent of its weight (0·5 gram of chrome iron ore was taken) of powdered charcoal and placed into the silver crucible, then five or six times the weight of caustic soda and about three times the weight of the substance taken of ammonium nitrate were placed upon the mineral in the crucible, and the whole heated gently at first, afterwards to redness for half-an-hour or so, over the ordinary Bunsen burner. The cooled mass was afterwards extracted with water, filtered, and the solution evaporated down to dryness in a platinum basin, with ammonium nitrate to separate the alumina and silica, which were then filtered off. The filtrate from this treatment was rendered acid with hydrochloric acid, when *chromic chloride* was at once obtained without reduction by means of a reducing medium, and the chromium was precipitated out by means of ammonia, filtered off, the precipitate dried, ignited, and weighed as Cr_2O_3. I cannot at present explain this remarkable reduction of the chromic acid, because in some experiments I had to employ a reducing medium as usual, such as boiling the acid solution with a little alcohol. I hope to investigate this reaction further. The results obtained are as follow, viz :—

Cr_2O_3	43·40
FeO	19·44
MgO	8·86
Alumina and Silica	28·30
	100·00

After the fusion and extraction with water, the insoluble matter on the filter paper was ferric oxide, magnesium carbonate, carbon, &c.

Qualitative Experiments.

Rutile (TiO_2) was at once decomposed and titanate of sodium produced, which, on being acidified with hydrochloric acid, gave the various reactions for titanium; for instance, a portion of the solution on having a piece of metallic tin placed in it gave a fine purplish-red coloured solution.

Titanate of Iron or Ilmenite gave the same reactions for titanium. It was easily attacked by the method.

Barytes ($BaSO_4$) gave insoluble carbonate of barium which was then filtered off and dissolved in hydrochloric acid and tested with sulphuric acid, when it at once furnished a precipitate of barium sulphate. The filtrate from the barium carbonate on being tested with hydrochloric acid did not give off any sulphuretted hydrogen, proving the *absence* of sodium sulphide, therefore no *reduction* of the sulphuric acid had taken place. On testing the acidified solution sulphuric acid was detected in large amount, consequently sodium sulphate had been found.

Simple silicates such as kaolin (china-clay), talc, cyanite, &c., and double silicates such as tourmaline, hornblende, garnet, &c., are split up and rendered soluble just as easily as any of the other minerals mentioned above. I hope at some future time to lay before the Society a more extended series of analyses of metallic ores and silicates, also of some minerals containing fluorine, by the new method, and in concluding this communication I must express my thanks to my young assistant, Mr. Gilbert Rigg, who has carried out my instructions with great intelligence and enthusiasm.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, March 10th, 1890.

Mr. J. C. MELVILL, M.A., F.L.S., President of the Section, in the Chair.

There were exhibited by Mr. H. HYDE a specimen of the fruit of *Luffa Ægyptiaca*; by Mr. CURTIS, a number of minerals; and, under the microscope, by Mr. H. C. CHADWICK, a stained preparation of *Flustra foliacea*, with the polypes extended. In this mount various stages of development of individual polypes were clearly demonstrated. Mr. J. C. MELVILL showed a specimen of *Disa grandiflora*, from Table Mountain, South Africa, also a coloured drawing taken from a living flowering plant, and made the following communication, "On *Disa uniflora* (Berg.), *grandiflora* (Linn. *fil.*)":—

"The magnificent orchid of which I am exhibiting a specimen, and also a drawing, is well known as one of the chief, if not *the* chief, of the floral glories of the Cape Peninsula. For years it has been generally termed *Disa grandiflora* (Linn.), but this name must yield to *D. uniflora* (Bergius), that writer, who likewise founded the genus, having described it in 1767, whilst the better known name bears date 1781, or fourteen years later. Both are appropriate to the normal condition of the plant, but sometimes it bears two, or even three flowers when in cultivation. The *Orchideæ*, so much sought after by collectors of late years, have been proved one of the largest families in the world as regards the number of species. The latest census is that of Bentham and Hooker, in Vol. III., 'Genera Plantarum,' 1883, who consider there are at least 5,000 'bene distinguendæ,' and the number is being augmented yearly. The order, therefore, at present stands third for size in the vegetable kingdom, so far as the Phanerogamia are concerned, being only surpassed by *Compositæ*, with over 10,000, and *Leguminosæ*, 7,500 species. The *Graminaceæ* were long considered third in size, but have had to yield to *Orchideæ*.

"In the 'Genera Plantarum' just cited, 334 genera of Orchids are admitted, which allows an average of about fifteen species to a genus, and the order is subdivided into five tribes. With only *four* of these tribes is the Cape Flora acquainted. According to Mr. Harry Bolus' last catalogue (1889), twenty-nine genera alone are present in South Africa, divided as follows:—

(i.) *Epidendreæ*.

"Three Cape genera, seven species Epiphytal, all but one in sub-tropical eastern districts.

(ii.) *Vandeæ*.

"Six Cape Genera. Sixty-nine species, mostly sub-tropical and in the eastern districts.

(iii.) *Neottieæ*.

"Two Cape genera. Two species terrestrial.

(iv.) *Ophrydeæ*.

"Eighteen Cape genera. Two hundred and fifty-two species, all terrestrial, and distributed over the whole area.

"It is with this latter tribe we have to deal at present.*

"The *Ophrydeæ* are distinguished as a tribe by the single anther being entirely aduite to the column, and having the pollen-masses, which are composed of viscid granules, stipitite. The four divisions of the *Ophrydeæ* are:—

(*a*) *Serapieæ*.

"Four genera, all European. *Orchis*, *Aceras*, *Ophrys*, and *Serapias*, the first three being common in this country.

(*b*) *Habenarieæ*.

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*The remaining tribe *Cypripedieæ* is not found in South Africa. In this section the plant has two anthers.

"Thirteen genera. One, *Herminium*, common to this country and the Cape; another, *Habenaria*, ubiquitous in every part of the known world, a few, *e.g.*, *Stenoglottis*, *Bartholina*, one of the most marvellous flowers of the tribe [*B. pectinata* R. Br.] of which I exhibit a specimen, conspicuous for its lacerated and fringed labellum, *Huttonæa* and *Holothrix*, being confined to the Cape, whilst *Diplomeris* is only known in the Himalayas.

(*c*) *Diseæ.*

"Fifteen genera (eleven according to H. Bolus), nearly restricted to south and sub-tropical Africa, with Madagascar.

(*d*) *Corycieæ.*

"Four genera. Three confined to South Africa; the fourth (*Disperis*) having its headquarters in the same region, is more extended in its range, a few being found in Mauritius and the East Indies.

"The third sub-tribe, the *Diseæ*, have alone to be considered at present. Here the anther is not erect, as in the two first divisions, *Serapieæ* and *Habenarieæ*, but is inclined, or more rarely sub-erect, usually being reflexed towards the back of the column. Of the fifteen genera, by far the largest is *Disa* (Bergius). This genus, as I have already said, is entirely confined to the southern portion of Africa (and I believe one species has been lately described from Madagascar), and contains one hundred species. Mr. H. Bolus has studied the various forms *in situ* more advantageously than any other botanist, and he is inclined now to merge several genera admitted by Bentham and Hooker, and separated for some slight floral differences. *Monadenia* (Lindley), *Schizodium* (Lindley), *Herschelia* (*ib.*), are by him treated as sub-genera only. As it stands, the genus is extremely varied in appearance, and is subdivided by Mr. Bolus into eleven groups. Some species, *e.g.*, *D. chrysostachya* (Lindley), *D. polygonoïdes* (Lindley), are densely spiked with small flowers; others, *e.g.*, *D. rosea* (Lindley), with few and slightly pendulous flowers; and *D. uniflora* (Berg.) stands out in the magnitude of its flowers, nearly solitary, but occasionally with two or even three on one footstalk. We can trace the links this very distinct plant bears to its other associates through *D. macrantha* (Thunberg), *D. racemosa* (Linn. *f.*) = *secunda* (Thunb.)

"The following letters may be interesting, as showing the effect in the minds of two botanists, already surfeited with strange plant forms, who visited Table Mountain together, over fifty years ago, to gather this orchid for the first time. In March, 1838, the late Dr. W. H. Harvey wrote from Cape Town to N. B. Ward, Esq.:—*

"You will be glad to hear that I have found a very pleasant botanical friend in a Mr. Bunbury, who has come out with General Napier on a pleasure tour. It is quite refreshing to meet a real botanist after so long a fast. We were up Table Mountain last week just in time to gather the last remaining flowers of *Disa grandiflora*. When I have my (Wardian) case made, I shall attempt to put *Disa grandiflora* in its natural circumstances, and try whether it will blossom with more success. If you have living plants of it at Loddiges' perhaps you may wish to know what the natural localities of this plant are. First, as all the world knows, it grows on the summit of Table Mountain, and nowhere else. This summit is very frequently enveloped in mist, especially at the season when the *Disa* blossoms. But it is very cold also, and the mist comes accompanied with a strong S.E. wind. After this succeeds the scorching sun of Lat. 33. So much for general circumstances: the particular ones are, that the plant *only* grows along the steep, boggy, spongy margins of a stream which has water in it *at all seasons*, but which in winter must be so swollen as to cover the plant. Here, the margin is completely clothed with the *Disa* to the exclusion of other plants. But immediately beyond the *Disa* is a margin of *Restios*, which, growing taller than the *Disa* and bending over the stream, afford considerable shade to the roots and leaves, at the same time that they leave the flower stalks room to peep out at the sun and exhibit their large blossoms.

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* Memoir of Dr. Harvey, London, Bell & Daldy, 1869, pp. 102, 103.

All these, except the cold wind, can be easily managed in a case, and I should hope that our plant would have the good taste to forgive us that part. The shade, moist atmosphere, and soil seem the chief things to provide.

"Mr. (afterwards Sir Charles James Fox) Bunbury, F.R.S., of Barton Hall, Suffolk, who accompanied Dr. Harvey to explore Table Mountain, has thus in turn recorded his impressions of this Orchid.*

"Next to the Ixias, the plants of the Orchid tribe deserve especial mention. By far the finest of them is the *Disa grandiflora*, the glory of Table Mountain, and certainly one of the most brilliant flowers I ever saw; it grows only in a marshy hollow near the south-eastern extremity of the summit of the mountain,† where it is pretty plentiful among the rushes on the margins of small pools and streamlets, in a black, boggy soil. No plant is more strictly local. In its colours it reminds me much of the well-known Mexican *Tigridia*, common in our gardens, but its scarlet is far more vivid. Several other interesting species of *Disa* are found at the top of the same mountain, and other in the flats, together with some large and showy kinds of Satyrium.

"Mr. H. Bolus gives 'Cold Bokkeveld' and 'Cederbergen' as localities for this plant in addition to Table Mountain. Both ranges are part of the same chain, the Cederberg range being about one hundred and thirty miles N. of Capetown, to W. of the town of Clanwilliam, and the Koude Bokkeveld a range trending off to the S.E. of Cederberg, due S. of the town of Tulbagh, and about eighty miles E.N.E. of Capetown. The *Disa* is getting so rare on Table Mountain, owing to constant onslaughts, that I lately heard that the Cape Government have wisely determined to protect it, as the Edelweiss is protected in Switzerland, and penalties are to be inflicted on the depredators. No quarter of the world produces more endemic rarities and peculiar species than the immediate neighbourhood of Capetown; and it would be an occasion for lasting regret if this, the most beautiful, perhaps, in a Flora where all is beautiful, should at any time become extinct. I do not know to what extent it is found on the Cederberg or Koude Bokkeveld ranges, but I take it to be very local there also. The drawing I am exhibiting to-night was taken by my sister from a living specimen grown by Capt. Osborne, at Gosport, Hants, from specimens obtained at Table Mountain, and the dried specimen was kindly sent to me, with many other Cape species, by my friend, Prof. P. Macowan, curator of the Botanic Gardens, Cape Town, who is now distributing yearly a 'Herbarium Normale Capense.' With care and protection in the winter, there is no reason why the *Disa* should not thrive in our gardens. For other descriptions, notes, and delineations of this fine plant, *c.f.* Thunberg 'Flora Capensis,' *Botanical Register* (1825), t. 926. Lindley, Sert: Orchid. (1838), t. 49. *Bot. Mag.*, t. 4073."

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* Hooker, Lond.: Journ. Bot. Vol. I. 1842.

† At 3,582 feet elevation (Balfour).

Besides the *Disa*, specimens of most of the other S. African species of *Orchideæ* were exhibited.

Ordinary Meeting, March 18th, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

Professor W. C. WILLIAMSON, F.R.S., alluded to the new doctrine of the growth of pith in the fossil forms of exogenous plants which he had recently put forward before the Royal Society. The plants to which the doctrine is applied now only exist as club mosses, ferns, and so on, but once reached the size of forest trees and found their support in the pith formation to which Dr. Williamson has called attention. Mr. CHARLES BAILEY, F.L.S., remarked that the modern and comparatively dwarfed forms must be regarded as cases of degeneracy.

Mr. W. H. JOHNSON, B.Sc., exhibited an improved form of gauge for measuring the thickness of metal sheets, rods, and other substances from three-fourths to at least one ten-thousandth part of an inch. Mr. JOHNSON briefly sketched the history of measuring, from the origin of the foot and inch, and pointed out that the workers in metal must, from a very early time, have required much more accurate means of measurement than other artisans. Wire drawing is a very old industry, and it is remarkable that in Africa Livingstone saw wire drawn by a method the same in principle as the most modern methods, with the exception that machinery worked by power is used in the latter. The process of wire drawing came to England from Westphalia during the last century. The sizes were known by names before the modern nomenclature by numbers, one of which, that of "six-band," still remains as a name for No. 22 gauge in brass wire. The development of submarine telegraphy necessitated, twenty-five years ago, a still more accurate measurement of wires. Mr. JOHNSON exhibited the different forms of gauge down to the screw gauge. His own new gauge is an adaptation of the micrometer screw which, for certain practical purposes, is handier than Sir Joseph Whitworth's, and was made under Mr. JOHNSON'S instructions. It consists of two short pillars, in one of which a stud is fixed, and on the other a horizontal screw with a pitch ·020″ works. A barrel about 2″ diameter is mounted on the screw; the circumference of the barrel is very carefully divided, first into divisions which represent ·001″ and then again into divisions representing ·0001″. The smallest divisions are about $\frac{1}{32}''$ apart. The article to be measured is placed between the fixed stud and the end of the horizontal screw and the measurement read off on the barrel. As the divisions reading ·0001″ are $\frac{1}{32}''$ apart, a difference of even $\frac{1}{3000}''$ can be easily detected. Mr. JOHNSON illustrated the delicacy of the instrument by reading off the increase in length of a small piece of metal held for a few seconds over a lamp. An animated discussion on the reliability of measurements of more minute differences, with special reference to Sir Joseph Whitworth's machine, ensued, Mr. JOHNSON expressing scepticism.—Dr. WILLIAMSON asked how it is possible to make mechanical arrangements so perfect as to measure quantities which it is only possible to see under the highest powers of the microscope, as for instance in the case of a diffraction grating?—Mr. GWYTHER pointed out that the diffraction gratings are themselves cut by the aid of mechanical apparatus of similar construction.—The PRESIDENT remarked that, as Sir Joseph Whitworth maintained, the accuracy of using all instruments of the kind depends upon the cultivation of a delicate sense of touch, and that, since Whitworth, no one has professed to use his instruments with the accuracy to which he had trained himself.

Dr. ALEXANDER HODGKINSON read a paper on

"Absorption Spectra and a method for their more accurate determination." He pointed out that the value and importance of radiation spectra are dependent on the constancy and accuracy of their spectral lines. In the case of absorption spectra, as observed in the ordinary way, no such constancy exists, the position of the absorption bands varying with the strength or thickness of the absorbing medium, and disappearing altogether when this is weak or thin. The width of the bands, moreover, is thus rendered unsuitable for comparison. By employing wedge-shaped absorption cells, however, wedge-shaped absorption bands are produced; and by ascertaining the point of convergence of the sides of these, the point of maximum absorption is obtained, and from this the line of maximum absorption. This may be termed a primitive absorption band. Evidence was adduced to show that the position of these primitive bands was constant for all strengths or thicknesses of the absorbing media, and for any angle of a hollow prism containing such media. A primitive spectrum consisting of these bands might therefore be accepted as proof of the identity of the body producing it. Diagrams of the spectrum of blood under the varying conditions necessary to prove the truth of these results were exhibited, and Dr. Hodgkinson stated that he had satisfied himself that the accuracy of the method approched that of radiation spectroscopy, and that the minutest trace of blood would be sufficient for observation. In the discussion which ensued, the possible application of the method to criminal and medical investigation, as in the cases of poisoning and bloodstains, was referred to.

Ordinary Meeting, April 1st, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

Dr. ALEXANDER HODGKINSON read a note on "Diamonds and double refraction." He pointed out that a distinguishing feature of the diamond, according to numerous popular works on the subject, is said to be that it does not exhibit double refraction or possess the power of polarising light. Having been working with diamonds in connection with an investigation of "Newton's rings," he had noticed that this was not correct. By the kindness of Messrs. John Hall and Co., of King Street, Manchester, he had had the opportunity of examining a very considerable number of large and small diamonds from various localities, which showed that, so far from diamonds of undoubted authenticity being necessarily single refracting, 63 per cent of the stones exhibited marked double refraction. Thus, of 15 diamonds from the Jagersfontein Mine, eight were double refracting; and of five specially large diamonds from the same mine, five exhibited the phenomenon. Of five ordinary sized diamonds from the Kimberley Mine five were double refracting, and of five from another mine four showed the same characteristic. The phenomen was shown to have some relation to the cavities common in diamonds. It allies itself rather with the state of glass under pressure than with the usual double refraction in crystals, and seems connected with inequality in the state of internal stress. A similar condition can be shown, as was demonstrated, in other naturally single refracting bodies, by rapid cooling or by compression. The important practical inference is that a body which exhibits double refraction or polarisation is not, as is commonly stated, therefore necessarily not a diamond. Dr. Hodgkinson pointed out that the double refraction is related to the form of the stones. Referring to the theory that the Koh-i-Noor is only a fragment of an enormously large diamond, of which other celebrated Indian diamonds were also originally parts, he suggested that its truth might be tested by ascertaining if a peculiar cross-shaped figure, produced by the absorption of light when examined under the microscope, was completed by bringing the alleged broken pieces together. A discussion ensued, during which Dr. BURGHARDT remarked that the diamonds examined appeared to have been chiefly Cape diamonds, and he suggested that Brazilian diamonds would not exhibit the same phenomenon. He added that a similar investigation had been communicated to the French Mineralogical Society in 1880 by Dr. Jannetaz, and that it was probable that the structure of a diamond was not so simple as appears from its common description as belonging to the regular system.

Dr. W. G. BLACK, F.R.Met.S., introduced by Mr. R. F. GWYTHER, M.A., read a paper on "Meteorology at the seaside," with special reference to the English Channel, in which he gave the results of an investigation of the barometrical, thermometrical, evaporation, sea temperature, and ozone conditions at Brighton, Hastings, Havre, and Boulogne during August, September, and October. He pointed out that there was a marked drop in all the curves about the time of the autumnal equinox, which coincides with the time when bathers and other visitors "by a kind of instinct" all leave these health resorts, and the local caterers for their entertainment close up for the season. The disappearance of the ozone, for instance, without any decided storm and without recovering itself, is very marked. Dr. Black also gave some interesting measurements of the height of the various forms of waves and the force of the backwash, pointing out the conditions under which bathing is dangerous, and the reason. In the case of crested waves and surge rollers, for instance, there is a strong undercurrent which tends to submerge the bather and carry him out to sea. He found that the specific gravity of the English Channel is very variable, increasing after a storm and diminishing in fair weather. This is doubtless caused by a greater amount of heavy sea water being brought in from the Atlantic than is neutralised by the excess of rainfall. He also pointed out that his readings of wind pressure in the open gave a much lower pressure than is commonly supposed to exist, as he rarely got a pressure of more than 6lb. or 8lb. A set of portable instruments for use in such investigations, being adapted for service in hotels, on piers, and on board ship, where the conveniences of an observatory are not available, was exhibited.

Ordinary Meeting, April 15th, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., President, in the Chair.

Mr. HARRY GRIMSHAW, F.C.S., stated that he was engaged in inquiries respecting the hygrometric properties of the Lancashire atmosphere, as compared with the United States, with special reference to the cotton-spinning industry, and that he would be glad to receive information as to where reliable meteorological records for Bolton and Blackburn could be found.

Mr. J. J. ASHWORTH stated that he had recently made inquiries from a Denton manufacturer with a view to ascertaining if there had been any tendency to increase in the average size of heads since the passing of the Education Act. He had been surprised to find that the books revealed a well-marked decrease. A discussion ensued, during which Mr. W. H. JOHNSON suggested that the phenomenon might be due to the alleged average decrease in stature with the extension of manufacturing industry and town life. It was also pointed out that in recent years there had been a tendency to have the hair of the head cut more closely than formerly, which might possibly be the explanation of the apparent diminution.

Dr. CHARLES JOHN HALL read a paper on "Thomas Augustine Arne as an Inventor of Musical Form," in which he claimed for Arne the invention of the modern binary form. Dr. Hall illustrated his paper by playing selections from the overture to "Artaxerxes" and the sixth of Arne's sonatas, in contrast with the older Handelian form. In the discussion which ensued, Mr. FARADAY drew attention to the analogies between the physics of music and chemistry suggested by Newlands and Mendelejeff's "periodic law" of the elements, and asked whether, if the chemist attempted to repeat a musical composition in forming compounds from what might be spoken of as a chemical key-board, interesting results might not be obtained? It was suggested that the time of the musical notes, for instance, in the experiment on chemical compositions, might be represented by relatively proportionate quantities of the elements—or of the energy of which they are the expression—taken as the prototypes of particular notes in the musical octave.

Thomas Augustine Arne as an Inventor of Musical Form. By Charles John Hall, D.Mus. Lond.

(*Received April 15th, 1890.*)

I fancy some sort of apology is due to you for my introducing here a subject which, although the Society has existed for so many years, has never before appeared on the agenda paper; and, in this historic chamber, with the counterfeit presentments of John Dalton and James Prescott Joule looking down upon me, I feel that, in asking you to listen to some remarks on a musical composer, I am departing from your traditions. I have, however, no diffidence in so doing, inasmuch as, although I am one of your most recently elected members—this is, in fact, my first appearance here—I think that while the literary and scientific sides of our association are well cared for and can boast of many eminent names, the art side is open to some development, while it is yet entirely within the scope and objects of the institution. This view has induced me to bring before you to-night some ideas connected with music, which is at once an art and a science. It may in fact be regarded as a triangular subject, having its practical, its theoretical, and also its physical sides. Music appeals to the senses through the medium of sound, and the laws of sound must, therefore, have an important bearing on the laws of music. I grant that musical composers, until very recently, knew practically nothing at all about acoustics, and wrote music not the less valuable on that account. Still, they only worked by rule of thumb; they knew from experience and practice that a particular combination of sounds was harsh and grating to the ear; they knew the difference between the tone of a violin and a flute; they knew, possibly, that a couple of similar organ pipes producing the same note, if placed in juxtaposition, might neutralise and not reinforce each other; but of the laws which explained these phenomena they were absolutely ignorant. From the time of Pythagoras physicists have known something about musical consonances in relation to arithmetical ratios, and musical theorists have had vague notions about harmonics and resultant tones; but it was reserved for Helmholtz to weld into a composite whole physical acoustics, on the one hand, and musical theory, on the other. How splendidly he has accomplished his task I need not say. But the existence of his book is, I submit, a complete answer to any who would doubt the propriety of my introducing here the subject of music. This close connection between the art of music and the science of acoustics is, I think, now universally recognized by musicians; but the recognition has been somewhat tardily and grudgingly given. I remember an eminent musician, who has not long gone to his last resting place, saying that acoustics had no more to do with music than astronomy. The simile was entirely unfortunate, for astronomy, as studied by the Greeks, was only a branch of music. The motion of the planets was regulated, they imagined, by musical intervals, and it is thus that the expression "music of the spheres" has crept into common use. Again, writing as late as 1874, an accomplished musical antiquarian showed an extraordinary want of appreciation of Helmholtz and his theories. Of one, he says "*Were it so, there would indeed be a jargon*," and "They (the scientists) attribute the various qualities of tone in musical instruments to *differences* in their harmonics." Nothing is so misleading as half the truth. What Helmholtz contended for, and what any one who has taken the trouble to test his experiments can prove to demonstration is, that the quality of tone is dependent upon the presence and *relative intensity* of harmonics. And I remember a discussion some years ago, in which it was solemnly advanced by one disputant that light had a great deal to do with the propagation of sound, because he found the best place for hearing in one of the large opera houses in London was over a large chandelier. Of course it was the heat and not the light that improved the acoustic qualities of that particular spot. I agree with Sir W. Herschell, who says: "The sense of harmony depends upon the periodical recurrence of coincidental impulses on the ear, and affords, perhaps, the only instance of a sensation for whose pleasing impression a distinct and intelligible reason can be assigned." Helmholtz modestly calls his discoveries in acoustic science, the lowest grade of musical grammar. Be the position of science in regard to music what it may, to such a discoverer as Helmholtz, and to such authorities as Tyndall, Sidley, Taylor, Koenig, and Dr. Stone, and in the more mathematical department to Lord Rayleigh, Sir Geo. Airey, and Professors Donkin and Everett, the musical world owes a debt of gratitude, the full measure of which I do not think it even yet fully appreciates.

Not so intimately connected with physical science, but still nearly attached to it, is the æsthetic aspect of music. This largely deals with questions of musical form, and I think I am as much entitled to ask you (as I shall do presently) to pause for a few moments to look at the structure of a piece of music, as others more learned than I may ask your attention to that of a rare plant or a newly discovered chemical substance. So, having, to my own satisfaction at least, shown that music, which is but the discipline of sound, is a subject well within your domain and purview, I now introduce to your notice Thomas Augustine Arne, the greatest English musician of the last century, He stands out as a figure of great artistic interest, as a bold and successful experimenter, and as a melodist of the highest order. English music owes as much to the Arne of the 18th as to the Purcell of the 17th century. Everyone now-a-days acknowledges Arne to have been the author of graceful airs, as elegant as any emanating from the Continent, and yet possessing that diatonic flavour which is an essential characteristic of true English melody; but, as an independent thinker and as an inventor of musical form, Arne has never, I submit, received his full meed of praise, and I claim for him that, whilst the fluency of his diction is admitted on all hands, the originality of his structural powers has been somewhat overlooked. It is this side of the man's genius that I now purpose to examine, and I am not therefore going to give anything like a detailed biographical account of Arne's life. Those who may feel interested in it will find an admirable summary in Dr. Busby's history of music, published in 1819, or in a more accessible form in the article "Arne," by Mr. Barclay Squire, in the new "Dictionary of National Biography." But it is of course necessary for me to refer to and bear in mind some facts and dates in connection with Arne's career. He was born in the spring of 1710, and in due course his father, who was a well-to-do upholsterer in Covent Garden, sent him to Eton, where his musical proclivities soon began to exhibit themselves, to the discomfort of his fellows, Arne being much given to playing the flute. Leaving Eton, he entered a solicitor's office, being destined by his father for a legal career, but as in the case of many other musicians, such as Schumann and the late Henry Smart, both of whom were intended for the legal profession, the claims of music proved too strong. The father, after a period of fruitless opposition, gave way, and the son was allowed to study music to the top of his bent. In 1733, he produced his first opera, "Rosamond." Now, let us see what, at that time, were his musical surroundings and the influences under which he was living and working. Purcell had been dead 38 years, but Arne had doubtless studied (only to admire) his sterling music, for, later in life, he, in fact, revived Purcell's finest opera, "King Arthur." Amongst leading contemporary English musicians must be named Greene and Boyce, both essentially cathedral men, though Boyce composed music for the stage as well. Greene was then in his prime, and had just been elected Professor of Music at Cambridge, but he had written nothing of moment save an Ode on St. Cecilia's Day, which cannot have influenced Arne in any way. Boyce was of the same age as Arne, and at this time had done nothing as a composer. So much, or rather, so little, for our native composers. But the giant Handel was here still, busily engaged in writing and producing Italian operas, and by his forceful presence and genius completely overshadowing all other musicians. That Arne often heard his works is clear, for he habitually borrowed a servant's livery in order to gain admission to the opera house, the liveried servants of the nobility being then entitled to free access to the gallery. Ariosti, vanquished by Handel, had left England five years before, and Buononcini was in disgrace, it having been then lately discovered that a madrigal which he had endeavoured to palm off on the public as his own was in reality the composition of Lotti. Greene had been made Buononcini's catspaw in this fraud, and on the latter being expelled from the Academy of Music, Greene and his friend Festing (Arne's violin master) also withdrew, and established rival concerts at the Devil Tavern, near Temple Bar, which made Handel remark that "Toctor Greene had gone to te Tevil." So, practically, all Arne could learn in the way of hearing music was from Handel. To study theory there was little book learning to be got beyond what could be gained from Morley's treatise, published 36 years before. Lampe, who published a theoretical work in 1737, however, influenced Arne, as the former's opera, "Amelia" (produced in 1732), brought before the public Arne's sister and pupil, Susanna (afterwards

Mrs. Cibber), and " Rosamond " was the immediate outcome of her success in "Amelia." But this influence was by way of suggestion and stimulation merely. Arne felt he could do better than Lampe, and (an important consideration) he had his *prima donna* ready in the person of a tractable relative. With the works of Corelli (who died in 1713) Arne had an intimate acquaintance, for both were violinists, and he doubtless knew something of Padre Martini, Galuppi, and Ricciotti, whose works had been published in England. Of Sebastian Bach, Arne at this time probably knew nothing, for, although some of Bach's cantatas had been published in Germany 18 years before, his music was slow to travel and popularise itself. But for Mendelssohn and Schumann I question if we should have known anything more of Bach than our countrymen did 150 years ago. If Arne, therefore, had been anything of a copyist he would have followed Corelli or Handel. Now, to a limited extent in his earlier works he does follow Handel, and it is interesting to see how his individuality gradually matures and asserts itself. This first appears in his masque of " Comus," written in 1736, and produced in the spring of 1738. To this work I must refer in some detail, and must preface my reference by a few words about musical form as applied to the overture.

Every musical piece, like a poem, a painting, or a building, must necessarily have a plan or design; and experience has shown that what is called the modern binary form is the best plan on which to lay out a classic overture. This is the scheme settled by Haydn and completed by Beethoven, since whose time no advance has been practicable. In this form two subjects are used. One commences the movement, the second is presently introduced in a related key, generally the dominant (*i.e.* the fifth above the key note), and shortly brings the first section to a close. In the second section these two subjects are developed and worked out according to the composer's genius and fancy, while, in the third section, the two subjects are recapitulated (the second now in the tonic key), and a coda, or tail piece, brings the movement to a conclusion. Now Handel worked on very different lines from these. In his day two forms of overture were known, the French and Italian. He followed the French model, which was to make the overture consist of four parts, (1) a short, solemn, and very slow movement, leading into (2) one of a lively fugal character founded on a single subject developed at some length, (3) another short and slow movement, and (4) a quick one in dance rhythm to conclude the piece. Those present who have frequented Sir Charles Hallé's concerts this winter may perhaps recall that that is the form in which the overture to "Theodora" is cast. The overture to the Occasional Oratorio you will all remember, and (except as to some limitation and variation in the third and fourth movements) this is the fixed Handelian form. It is adhered to by Arne in "Comus," and yet one feels on hearing it that it is not Handel's, the harmonies in the third and fourth bars of the initial *largo* at once arresting the attention as being removed from the commonplace. A brisk fugue follows, the viola having a perfectly independent part, and the 'cello being (for the very first time I believe) used here and elsewhere in this and many later works in the tenor register as a melodic instrument, the composer taking advantage of the presence in England of Cervello, one of the foremost 'cello players of his day. A bridge, three bars long, leads to the concluding movement—a fast one—contrasted in time with the preceding fugue. Arne at once dispenses with the customary third or slow movement of Handel, and if, as is occasionally the case in some subsequent overtures, he introduces this movement, he omits the opening *largo* altogether, thus inclining more to the Italian model, which consisted of two fast movements, with a slow one sandwiched between them. At any rate, even as early as "Comus," Arne was no mere slavish imitator, and in the vocal numbers he shows great power and versatility, and the liberty (in those days) of interpolating in a song a few bars with a time signature differing from that in which the song is commenced, is one of which Arne readily avails himself. No more charming pastoral music is to be found anywhere than in "Comus." One song at least, "Sweet echo, sweetest nymph," will probably be known to some of you. It has been said that Arne was not a sound contrapuntist. Is it because he has allowed a few consecutive fifths and sevenths to creep into his scores (*vide*, for instance, the song, "By the gaily circling glass," in "Comus")? If so, why even Handel himself is no sound contrapuntist. Why should a license be permitted to him and not to Arne? In his instrumentation of "Comus," Arne uses flutes (the flauto traverso), oboes, bassoon, trumpets and the string quintet.

About this time he married Miss Cecilia Young, a well-known actress, and the soprano songs in "Comus" are "sung by Mrs. Arne" Yet in the next work of his I propose to notice, "Alfred," Miss Young's name appears. Probably this was Miss Isabella Young, who afterwards sang in Arne's "Eliza." "Alfred" is a masque much on the same lines as "Comus," except that there is no opening slow movement in the overture, and the fugal movement is developed to much greater length than in "Comus." In the orchestration, flutes are dispensed with, but horns, kettle-drums, and a side drum are added. "Alfred" concludes with an air which has become a national anthem, "Rule Britannia." Could anything be more thoroughly original and permeated with English spirit than this inspiriting tune? After "Alfred," Arne turned his attention to Shakespeare, composing incidental music for "As you like it," and "Twelfth Night," and then "The Tempest," wherein, of course, occurs his still popular setting of "Where the bee sucks." In 1759, the degree of doctor of music was conferred on Arne by the Oxford University. In 1760, having meanwhile produced a couple of oratorios which did not achieve success, he wrote "Eliza," the overture to which (Handelian in form) concludes with a minuet as delightful as anything of the kind Mozart—who was then but two years old—ever wrote, and then transferred his services from Drury Lane, for which establishment he had hitherto been writing, to the rival house, Covent Garden, and there produced "Thomas and Sally," a work of little artistic value. Probably his mind was already full of the subject of "Artaxerxes," which he intended to be his masterpiece, and which was brought to a hearing two years later. This is an opera confessedly composed in the Italian style, and designedly intended to compete with Italian opera on its own ground. It was the first attempt to write what is called grand opera for the English stage, and contains much of the bravura writing traditionally and inseparably associated with Italian craftsmanship. It would have been better if Arne had retained his national simplicity of style. *That* was original. The other was but a clever imitation. One critic has expressed surprise that the "father of a style more natural and unaffected, more truly English than that of any other master, should have been the first to deviate into foreign finery and finesse, and desert the native simplicity of his country," and a more bilious and unfair writer said:—

> Let Tommy Arne, with usual pomp of style,
> Whose chief, whose only merit's to compile,
> Who, meanly pilfering here and there a bit,
> Deals music out as Murphy deals out wit,
> Publish proposals, lines for taste prescribe,
> And chant the praise of an Italian tribe.
> Let him reverse kind nature's first decrees,
> And teach e'en Brent a method not to please, &c.

Miss Brent was a talented pupil of Arne, and took the leading part in "Artaxerxes," which, notwithstanding all this adverse criticism, held the stage for eighty years, and would, I believe, even now be well worth reviving. The vocal forms herein show more continuity, development, consistency, and maturity than before, and one of the airs, "The soldier tired," is not only a model of *aria* form of an advanced order, but it has a splendid trumpet *obligato* accompaniment, and is, in fact, as fine an example as many existing of this class of music. Not only do the vocal forms in "Artaxerxes" mark a distinct advance, but in the overture (my main point) we also find the older traditions cast aside, and in their stead a clear-cut specimen of modern binary form substituted. In testing a piece for modern binary form, we have fortunately an infallible rule, as applicable to the early and naturally crude attempts in this direction as to the fully expanded form of Beethoven, viz., the presence of a second subject. No amount of fugal exposition will serve, no device of repeating the first subject in the key of the dominant will do; we must find, not a mere episode, but a distinct and separate second subject. Now this we do find in the "Artaxerxes" overture. The initial theme—one of eight bars—commences the work, without preface or introduction of any kind. Eight bars of episode lead us direct to the second subject—four bars repeated—which duly appears in the key of the dominant. Eight bars more, and we reach the termination of the first section. The second section, or "free fantasia" as it is called sometimes, occupies 57 bars, and is founded mainly upon the episode connecting the first and second subjects in the first section. The recapitulation, in which both subjects appear in proper order and key, has 37 bars, and thus concludes an overture, the claims of which as an epoch marker have, I think, been overlooked. This crucial second subject is not found in the writings of the 17th century composers, which Arne might have studied. He got it neither from Handel nor Sebastian Bach. C. P. E. Bach, though slightly younger than Arne, may fitly be called his contemporary, and to him is generally conceded the title of father of modern sonata form. Here the second subject fully appears. He was followed by Schobert, and one most learned writer says that the honour of having fixed the form may fairly be divided between these two composers. I think Arne's name should be added. Dr. Burney, writing in 1780, says Schobert published nothing till 1761. This statement has been challenged, and may be incorrect, but probably Burney was right to this extent, that nothing of Schobert's reached England till 1761. As to C. P. E. Bach, his sonatas were not published till 1766, so that when Arne produced "Artaxerxes" in all probability neither Schobert's nor C. P. E. Bach's works were known to him, and certainly nothing of Haydn's, who was then a young man of 28. In England there was no composer of note except Boyce, and he adhered to Handelian lines, and I think, therefore, it is a reasonable inference to draw from these dates that Arne's overture was an original conception in regard to form, and a distinct creation. Three years after "Artaxerxes" Arne produced "Elfrida." Here again we have the modern form. The overture commences at once *allegro* with an eight-bar subject in D minor. This is followed by an episode in the tonic major of 21 bars, when the first subject is repeated in the dominant minor, succeeded by a further episode leading to the second subject, eight bars in length, which is also in the dominant minor, and as to this being a real and true second subject there can be "no possible probable manner of doubt." The figures used in the preceding episodes supply (as in "Artaxerxes") the material for the customary development, leading to the return to the first subject in the original key, and the subsequent reiteration of the second subject in the same key, all according to modern orthodoxy. The importance of this overture as a formal invention is in no wise detracted from by the fact that there are two movements, an *andante* and a martial minuet (in "Artaxerxes" these are a *larghetto* and a *gavotte*) following the *allegro.* Generally, in regard to "Elfrida," one is struck in perusing the score with four things:—(1) the unusually lofty and dignified tone that pervades the whole; (2) the large use now made of accompanied recitative; (3) the extreme moderation of the composer in regard to Italian embellishments; and (4) the absence of a male chorus, female voices alone supplying this adjunct. It is said, by the way, that Arne was the first to employ female voices in oratorio choruses. I don't know what this phrase really means. Perhaps some kind critic will enlighten me. Arne was not in the habit of repeating himself, and it is therefore curious to notice that the opening phrase in the song "Monster away" in "Artaxerxes" is identical with that with which the fourth Act of "Elfrida" begins. In all his works the fitting character of the music to the sense and rhythm of the words is very observable, and yet in one song in "Elfrida" he throws the accent in the word "sonorous" on the first syllable.

I think with "Elfrida" Arne was at the zenith of his career as an inventor. Thenceforward, down to the time of his death in 1778, he produced a good many works, mostly of a light character. In the overture to "Caractacus" he attempts what is now called programme music. In that to "The Cooper" (1772) he gives us another specimen of modern binary form. Having enunciated his first theme, he proceeds through a short episode of sixteen bars direct to the second, the previous repetition of the first which is found in "Elfrida" being now dispensed with, and a freer use made of the first theme in the subsequent development. Theme No. 2 duly appears in the key of the tonic in the concluding section. Again an *andante* and minuet follow. It only wanted a finale to convert this overture into an unpretentious symphony. I may, just in passing, name another overture, that to "The Guardian Outwitted," of which (like "The Cooper") Arne was both author and composer, that has a truly Mozartean flavour. This opera is inscribed to the Queen. The dedicatory address is in the fulsome verbiage of the time. Arne as an author would *not* be a success to-day.

One branch of Arne's music (the Harpsichord Lessons) I have not touched upon, my purpose, as I have said, being to speak of Arne as an inventor and leader of musical thought, and not to detail his biography. But of these seven dainty sonatas as they are called, one—No. 6—contains a movement which also exhibits (in a most condensed and epitomised, but perfectly definite manner) the modern binary form. Arne's MS. scores were to a large extent destroyed in the fire which occurred at Covent Garden in 1808, but his oratorio, "Judith," is in the British Museum. One wonders how his oratorios would have fared had there been no Handel. The present Oxford professor of music has, I believe, expressed the opinion that the influence of Handel was adverse to the growth of British art, and there is no doubt this view is correct, and has very special reference to Arne. Arne was a bold man—his autograph lying here shows that,—and he did the work of a man who was not only bold but possessed of great genius. The words used in a letter I received the other day from an eminent musician are so apt, and so correctly estimate Arne and his work, that I quote them. My friend says, "Arne's advancement in the use of forms and detail arose not only in his quickened talents, but in his impulsive daring nature as a writer of music. It was prescience rather than knowledge which was the moving spring." Of late years much has been said and done in furtherance of a school of real English opera, but as yet we do not seem to have quite found the composer who is to regenerate us. We want a man whose name may be linked with those of Purcell and Arne, who must, like them, be an innovator and inventor, and who, whilst assimilating and adapting Continental methods, will still give expression to the national characteristics; for, although we have it on the authority of Rossini that there are but two schools of music, the good and the bad, yet most of us are strongly inclined to believe in the possibility of founding a British School which shall, despite the cosmopolitanism of music, faithfully reflect the national character, and be imbued with a national individuality—something less profound than German, more dignified than French, and more solid than what Italian art has given to the world. Three hundred years ago we were the foremost musical country in Christendom, and we take satisfaction in the truism that history repeats itself.

[*Microscopical and Natural History Section.*]

Annual Meeting, April 21st, 1890.

Mr. J. C. MELVILL, M.A., F.L.S., President of the Section, in the Chair.

Mr. W. RICHARDSON SCOWCROFT was elected an associate.

Mr. P. CAMERON showed specimens of *Aspidiotus theæ*, a scale insect from the tea plantations of northern India, and a *chalcid* parasitic on it, which has not yet been described; also a necklace from South Africa, composed of white ants' eggs.

Mr. E. PYEMONT COLLETT exhibited various species of *Aregma*, and Mr. THOMAS ROGERS exhibited young plants of *Gunnera scabra*, showing the water gland. A discussion ensuing on the presence of this plant in Guernsey, Mr. MELVILL mentioned that he had been informed a day or two before by the Rev. R. P. Murray, that he had seen an enormous stretch of down on the Pownall Hills, Somersetshire, covered with a dense growth of *Phlomis fruticosa*, which has been known there for several years and is still increasing. It is a native of the Mediterranean region of Southern Europe. *Bupleurum fructicosum* (L.) in the same way is plentifully established on the Malvern Hills, near the Herefordshire Beacon.

Mr. P. CAMERON read a paper entitled "*Hymenoptera Orientalis*, or contributions to a knowledge of the Hymenoptera of the Indian Zoological Region: Part II."

The Secretary read the thirty-second annual report of the Council of the Section, and the Treasurer submitted the annual balance sheet and statement of accounts.

On the motion of Mr. CHAS. BAILEY, F.L.S., seconded by Mr. T. ROGERS, the annual report and Treasurer's accounts were approved.

The following gentlemen were elected officers and memcers of the Council for the ensuing session:—

President:—ALEX. HODGKINSON, M.B., B.SC.

Vice-Presidents:—CHARLES BAILEY, F.L.S.; J. COSMO MELVILL, M.A., F.L.S.; W. C. WILLIAMSON, LL.D., F.R.S.

Treasurer:—MARK STIRRUP, F.G.S.

Secretary:—JOHN BOYD.

Other Members of the Council:—WILLIAM BLACKBURN, F.R.M.S.; P. CAMERON, F.E.S.; H. C. CHADWICK; ROBERT E. CUNLIFFE; R. D. DARBISHIRE, B.A., F.G S.; F. NICHOLSON, F.Z.S.; THOMAS ROGERS; THEODORE SINGTON.

Annual General Meeting, April 29th, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S.,
President, in the Chair.

The annual report of the Council was presented, and it was moved by Mr. CHARLES O'NEILL, F.C.S., seconded by Mr. ALFRED BROTHERS, F.R.A.S., and resolved, "That the Annual Report be adopted and printed in the Society's *Memoirs and Proceedings*."

It was moved by Mr. J. J. ASHWORTH, seconded by Mr. JOHN ANGELL, F.C.S., F.I.C., and resolved "That the system of electing Sectional Associates be continued during the ensuing session."

The following gentlemen were elected officers of the Society and members of the Council for the ensuing year:—

President:—EDWARD SCHUNCK, Ph.D., F.R.S., F.C.S.

Vice-Presidents:—WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S., Foreign Member of the Royal Swedish Acad. Sc., and of the Royal Society, Göttingen; OSBORNE REYNOLDS, M.A., LL.D., F.R.S.; ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S.; JAMES BOTTOMLEY, B.A., D.SC., F.C.S.

Secretaries:—FREDERICK JAMES FARADAY, F.L.S., F.S.S.; REGINALD F. GWYTHER, M.A.

Treasurer:—CHARLES BAILEY, F.L.S.

Librarian:—FRANCIS NICHOLSON, F.Z.S.

Other Members of the Council:—WILLIAM HENRY JOHNSON, B.SC.; JAMES COSMO MELVILL, M.A., F.L.S.; HAROLD B. DIXON, M.A., F.R.S.; ALEXANDER HODGKINSON, M.B., B.SC.; JOHN BOYD; JOHN F. W. TATHAM, B.A., M.D.

Ordinary Meeting, April 29th, 1890.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., President, in the Chair.

Mr. WILLIAM BROCKBANK, F.L.S., F.G.S., read a paper on "The Levenshulme Limestones," describing further evidence, revealed by the cutting of the new railway *via* Levenshulme and Fallowfield, in support of opinions advanced by the author in a communication read before the Society, March 6, 1883, and published in the *Memoirs*, Third Series, Vol. VIII.

Mr. P. CAMERON (introduced by Mr. JOHN BOYD) read a paper entitled "*Hymenoptera Orientalis;* or Contributions to a knowledge of the Hymenoptera of the Indian Zoological Region: Part II.," and exhibited specimens of several new species.

Professor HORACE LAMB, M.A., F.R.S., read a paper "On the Flexure of a Flat Elastic Spring."

Mr. SAMUEL OKELL, F.R.A.S., read a paper entitled "Description of a new Reflecting Telescope and Observatory at Bowdon, Cheshire."

The Levenshulme Limestones. By William Brockbank, F.L.S., F.G.S.

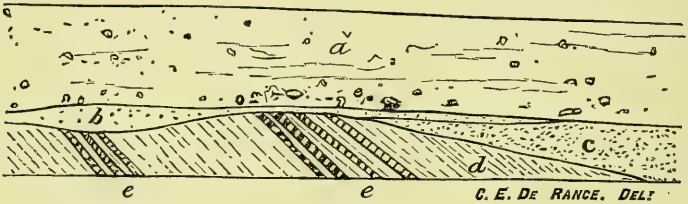
(*Received April 29th, 1890.*)

The Railway cutting now in progress from Fallowfield to Levenshulme has exposed a fine series of the Permian red and mottled sandstones, clays, and marls, similar to those referred to in the writer's communication printed in the Society's *Memoirs*, Third Series, Vol. VIII.

These beds have been carefully examined, at my request, by Mr. C. E. De Rance, F.G.S., of H.M. Geological Survey, who confirms the conclusions stated in that paper, the beds shewing well-marked evidences of their Permian character.

Within 50 yards of Slade Lane the section shews the junction between the Permians and the Upper Coal Measures. This was not disclosed by the sewering operations in Slade Lane, from which our previous knowledge was derived, and it could not, therefore, have been shown in the diagrams submitted to the Society in 1883. The line of sewer ran along the face of the outcrop of the limestones, and from this into the Permians, thus leaving its actual position in doubt. The interesting point of junction was discovered by Mr. De Rance, who at once recognized it from having seen exactly similar beds at Prescot, where they were found to contain fossils, which give them the name of the "Modiola-Macadami" beds, and which undoubtedly belong to the Upper Coal Measures.

Mr. De Rance has drawn up the following memorandum describing this part of the section: "The soft current-bedded red sandstone, probably the age of the Collyhurst sandstone, seen in the Railway cutting from a point about 50 yards west of Slade Lane to the Wilmslow Road at Fallowfield, exhibits no break in continuity (with the exception of two small faults), dipping W. or W.S.W. at an average of 14°. But, at the point named, about 50 yards west of Slade Lane, the base of the bright red sandstone is seen resting on, apparently, an eroded surface, sloping westward at 10°, of green and deep purple marls, and purple dark grits. These beds overlie several beds of the Levenshulme limestones with *Spirorbis carbonarius* and a band of calcareous ironstone, at the lowest point yet reached, which are, in my opinion, the Ardwick series of the Upper Coal Measures. They dip at a much higher angle than the overlying red-beds, which may indicate the presence of a fault, as suggested by Mr. Brockbank in 1883."



a. Boulder Clay.
b. Drift Sand.
c. Current-bedded red sandstone. Permian.
d. Purple and green marls, and fine purple grits, resembling the Modiola-Macadami beds of Sutton, near St. Helens.
e. The Levenshulme Limestones, probably the Ardwick Limestones of the Manchester Coal-field.

The cutting at Slade Lane has laid bare the outcrops of the several bands of limestone described in 1883, the upper limestone being flat bedded, from 2 to 8 in. thick, and plentifully mottled with circular greenish markings, which are popularly known as "fish eyes" in other localities. The lower seams are thicker, and contain great numbers of fossils.

The upper surfaces of the outcrop limestones were found to be much eroded, and many glacial scratch marks were clearly seen upon them. Boulders of granites, green-stones, brown hematite, and coal measure sandstones were also found lying immediately upon the rock, and much sand occurred at some points.

The cutting is not yet through the limestones. So far they bear a close resemblance to the Ardwick beds. Coal will probably be found within a workable distance below them, as with the Ardwick limestones and the Openshaw coals.

The junction between the Permians and the Upper Coal Measures is not now to be seen, as formerly, at Collyhurst. This gives a greater interest to the section of the Levenshulme limestones, which clears up a very difficult point. The Geological survey will have to be very materially altered, the maps to the south of Manchester having been prepared before the occurrence of the Permian beds and the Levenshulme Limestones had been ascertained. Mr. De Rance is now engaged on this matter, and I hope next session to lay some further information, and particulars of the fossils, before the Society.

Description of a New Reflecting Telescope and Observatory at Bowdon, Cheshire. By Samuel Okell, F.R.A.S.

(*Received April 29th, 1890.*)

Mr. Calver, of Chelmsford, has recently completed for me a new reflecting telescope of considerable dimensions. This telescope is of the Newtonian form, in which, as is now generally well known, the light is received on a mirror or speculum, so figured as to bring objects to a focus directly in front of itself. Near this focal point the image is received on a smaller plane mirror placed at an angle of 45°, and by this it is again reflected to the eyepiece which is fixed in the side of the upper portion of the main tube. The large mirror in the present case is 20½ inches in diameter and of 12 feet focal length, weighing nearly 100lbs., and is a choice specimen of the skill of the maker. Mr. Calver's abilities in the production of silvered glass mirrors are already well known to astronomers.

The mounting is equatoreal, of the German form, and is very massive and complete, the whole weighing between three and four tons. A concrete foundation some 8ft. below the surface forms the base. Upon this, solid brickwork is placed, containing a central chamber for the weights of the driving clock, and this supports a stone slab 4ft. 6in. by 3ft. 6in., upon which the bed plate of the telescope rests. The polar axis, 6in. diameter, and the declination axis, 4in. diameter, both move with great ease on friction pulleys. The tube, 22in. in internal diameter and 12ft. 6in. in length, being iron, and owing to its size and considerable weight, is provided with a novel mechanical appliance for bringing the eyepiece to the most convenient position for observing, by rotating in its cradle with worm and rackwork moved by a hand wheel. The right ascension and declination circles are 20in. diameter, the verniers reading to seconds and ten seconds respectively. Other considerable improvements introduced by Mr. Calver into the construction are seen in the driving clock, arranged to beat seconds when required on a small bell and with maintaining power to keep it going whilst being wound up; also in its direct connection with the hour circle. The clock is arranged to drive the hour circle continuously without carrying the telescope, and thus the hour setting can be done once for all to sidereal time for a whole night's work. Thus only right ascension setting is needed in finding any object, and, when found, the half turn of a handle attaches the telescope to the hour circle, and it is also carried along by the clockwork and the object is held centrally in the field of the eyepiece. There is also a special hand slow motion that can be applied without stopping the clock, either to accelerate or retard the motion, or to enable the observer to examine different portions of a large object without affecting the clock driving. This and a similar slow hand motion in declination are both brought up to, and can be applied from, the eyepiece by the observer, as occasion may require.

The various eyepieces provide magnifying powers ranging from 70 to 1,000 diameters. The performance of the telescope, so far as at present tested, is very satisfactory; observations on the Moon, Saturn, the great Nebulae in Orion, double stars, &c., have been made, and show how much may be expected from this noble instrument when the adjustments are completed, and good observing nights are obtained.

The observatory built for this telescope also presents some novel points in construction. The objects sought were, in the first place, to obtain a cheap and efficient structure, and secondly, one which would not require any great power to manipulate in moving the dome and shutter, which in so large a size would have required special arrangements if made in the ordinary way. The dome is composed of strong sail canvas stretched over a wooden framework, and may best be described as consisting of three flat zones, which form chords to the great circle. The main ribs run, that is half of them, from a semicircular frame at the top to the circular wooden ring which forms the base of the dome, the two horns of the semicircular frame being carried down parallel to form the opening, four feet wide, for observing purposes. The remaining half of the radial ribs run into, and are joined into, the sides of this opening. There are smaller cross ribs placed at intervals of 15 to 18 inches, both for the purpose of stiffening the whole structure and also to serve as further supports for the canvas. To add still more to the general strength, two strong iron stays are adapted to the shape internally, and run from the base to the middle of the side of the opening, one on each side of the observing slit at about an angle of 45°. The rail on which the dome revolves is fixed to the underside of the wooden circular base of the dome, the whole structure running round on six wheels bolted on to timbers built into the main circular brick walls of the observatory. The spindles of two of the wheels, one on each side of the house, are lengthened, and have hand wheels 2ft. 6in. diameter attached, by which the dome is very easily revolved. It will be noted that, the rail being attached to the dome, the wheels are stationary, the dome revolving over them; one advantage of this arrangement being, that the hand wheels for revolving the dome are always in the same position with respect to the walls, and may be found in dim light without difficulty, and another, that the walls are continued up close to the base of the dome; narrow oilcloth curtains attached to the inside and outside edges of which effectually cover the joining and keep out draughts. The shutter, which is also of canvas, is made on a framework of cross ribs of wood, with small wheels and clips at either end, the ribs being about 20 inches apart, and is stayed by strips of broad spring steel, which adapt themselves to the curve without strain. The whole runs on flat rails which are attached to the main ribs of the opening, and run down as flying rails on the opposite side of the dome, so that, as the shutter is drawn up by the ropes attached to it inside, it simply slides over the top. As the opening extends more than to the top centre of the dome so as to give ready access to the zenith, the lower portion of the shutter is arranged to open outwards on hinges. This is done to shorten the length of the main shutter and prevent its dipping below the skirt of the dome when opened to the fullest extent. The canvas is the strongest sailcloth, of which 160 yards were required ; it is rendered waterproof with several coatings of boiled oil, over which it has been painted a silver grey.

The dimensions of the observatory are 20ft. diameter internally, 22ft. externally, and 14ft. 6in. from the floor to the highest portion of the dome. A transit house on the west side, 8ft. by 4ft., contains a transit telescope by Dollond, 2½in. aperture, 30in. focal length, and completes the equipment.

Although primarily intended for general observational rather than micrometrical work, I propose, first, by watchful attention of the lunar surface during successive lunations, especially of such spots or craters as have already been suspected as showing signs of recent change, to aid in some small degree in obtaining the required information which will satisfactorily decide this important question. The planets will also receive a considerable amount of careful scrutiny, and such other objects as may from time to time claim special attention. This telescope, being particularly suited, owing to its perfect achromatism, for photographic purposes, a new branch of astronomical research which is capable of much greater development, I hope to devote some time and effort in this direction, and trust I may be able now and again to bring before you results which may be of interest and service in the general advancement of astronomical enquiry.

On the Flexure of a Flat Elastic Spring. By Horace Lamb, M.A., F.R.S.

(*Received April 29th, 1890.*)

It is a well known consequence of the ordinary theory of flexure that when a bar of (say) rectangular section is slightly bent by opposing couples in a plane parallel to one pair of faces, so as to form a circular arc of radius ρ, the remaining faces take an anticlastic curvature σ/ρ, where σ is "Poisson's ratio"; and this fact has been made the basis of ingenious experimental methods of determining σ, by Cornu* and Mallock†. It appears to have been first remarked by Thomson and Tait (*Natural Philosophy*, § 717) that this tendency to anticlastic curvature imposes in certain cases a limit to the degree of flexure, beyond which the theory in question will not apply. "For unless the *breadth* of the bar (or diameter perpendicular to the plane of flexure) be very small in comparison with the mean proportional between the radius [ρ/σ] and the thickness, the distances [in any cross section] from [a line through the axis perpendicular to the plane of flexure] to [one pair of corners] would fall short of the half-thickness, and the distances to [the other pair] would exceed it by differences comparable with its own amount. This would give rise to sensibly less and greater shortenings and stretchings in the filaments towards the corners than those expressed in our formulæ, and so vitiate the solution. Unhappily, mathematicians have not hitherto succeeded in solving, possibly not even tried to solve, the beautiful problem thus presented by the flexure of a broad very thin band (such as a watch-spring) into a circle of radius comparable with a third proportional to its thickness and its breadth."

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* *Comptes Rendus*, Aug. 2, 1869.

† *Proc. Roy. Soc.*, June 19, 1879.

The difficulty thus arising in the case of a straight band, when the flexure exceeds a certain amount, makes its appearance *ab initio*, even for infinitely small changes of curvature, in the case of a band originally curved, and is in this way closely connected with the circumstance, first pointed out by Mr. Love,* that it is in general impossible to satisfy the boundary conditions for a curved plate or shell by a deformation such that the middle surface is absolutely unextended. In considering this latter question I had occasion, recently,† to work out the uniform flexure of a cylindrical plate, but I did not notice at the time that the same analysis, with the proper change of meaning of a coefficient, gives the solution of the problem proposed by Thomson and Tait. As the matter is of independent interest, and as so much importance has been attached to it by these writers, I take the liberty of reproducing the investigation (as suitably modified) in a separate form. The main results are such as might be anticipated from the above quotation. The extensions and contractions of the middle surface of the band, which are called into play by the tendency to the contrary curvature in the direction of the breadth, keep this curvature in check, so that the strained form never deviates appreciably from that of a cylinder. When the radius ρ is large compared with the third proportional aforesaid, the couple required to maintain the flexure has the value given by the ordinary theory; whilst in the opposite extreme it tends to the value appropriate to a *plate*. For intermediate cases we must have recourse to the general formula (18) given below.

Considering, then, a straight flat spring whose breadth

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* *Phil. Trans.*, 1888 (A), pp. 521, 524.

† *Proc. Lond. Math. Soc.*, Jan. 1890. See also §7 of a previous paper "On the Flexure of an Elastic Plate," Dec., 1889.

$2b$ is large compared with the thickness $2h$, let us in the first instance suppose that by a proper application of force to the two ends (to be afterwards determined) it is bent so that the strained form is one of revolution. As regards the amount of the bending, we shall suppose only that ρ, the radius of curvature of the medial line or axis, is large compared with h. Let the band be divided into rectangular elements by two systems of normal sections respectively perpendicular and parallel to its length. The stresses across any section of the former system will reduce to a tension P, and a couple G, both reckoned per unit length; whilst across any section of the second system we shall have a tension Q, a couple H, and a shearing force Z in the direction of the normal. All these quantities are functions only of the distance (x, say) from the medial line. Considering the equilibrium of a rectangular element of breadth dx, and resolving parallel to x, we find

$$\frac{dQ}{dx}=0,$$

and since Q vanishes at the free edges, it follows that

$$Q=0 \qquad (1)$$

everywhere. Again, resolving along the normal, we have

$$\frac{dZ}{dx}-\frac{P}{\rho}=0;$$

and taking moments about a parallel to the medial line,

$$\frac{dH}{dx}-Z=0.$$

Hence

$$\frac{d^2H}{dx^2}-\frac{P}{\rho}=0. \qquad (2)$$

The remaining boundary conditions are evidently $H=0$ $Z=0$, that is

$$H=0,\ \frac{dH}{dx}=0. \qquad (3)$$

The functions which occur in these equations have now to be expressed in terms of the deformation of the middle surface of the band. If a rectangular plate of thickness $2h$ undergo extensions σ_1, σ_2 parallel to the edges, the corresponding tensions are, per unit length,

$$\left.\begin{aligned} P &= \frac{4(\lambda+\mu)\mu}{\lambda+2\mu}(\sigma_1+\sigma\sigma_2)\,.\,2h \\ Q &= \frac{(4\lambda+\mu)\mu}{\lambda+2\mu}(\sigma_2+\sigma\sigma_1)\,.\,2h \end{aligned}\right\} \qquad (4)$$

when λ, μ are the elastic constants of Lamé, equivalent to $m-n$ and n, respectively, in the notation of Thomson and Tait. If, further, the plate experience curvatures $1/\rho_1$ and $1/\rho_2$ parallel to its edges, the corresponding flexual couples are

$$\left.\begin{aligned} G &= \frac{4(\lambda+\mu)\mu}{\lambda+2\mu}\left(\frac{1}{\rho_1}+\frac{\sigma}{\rho_2}\right).\frac{2h^3}{3} \\ H &= \frac{4(\lambda+\mu)\mu}{\lambda+2\mu}\left(\frac{1}{\rho_2}+\frac{\sigma}{\rho_1}\right).\frac{2h^3}{3} \end{aligned}\right\} \qquad (5)$$

Now let w denote the deviation at any point of the middle surface from the cylindrical surface (of radius ρ) drawn through the medial line, in the strained condition; and let σ_0 be the extension of this medial line. We have evidently, in the present case,

$$\left.\begin{aligned} \sigma_1 &= \sigma_0 + w/\rho \\ \rho_1 &= \rho + w \\ 1/\rho_2 &= -d^2w/dx^2 \end{aligned}\right\} \qquad (6)$$

The equations (1) and (4) show that

$$\sigma_2 = -\sigma\sigma_1,$$

and substituting from (4), (5), and (6), in (2), we get

$$\frac{h^2}{3}\frac{d^2}{dx^2}\left(\frac{d^2w}{dx^2}-\frac{\sigma}{\rho+w}\right)+\frac{1-\sigma^2}{\rho}\left(\sigma_0+\frac{w}{\rho}\right)=0.$$

An error of the order w/ρ in the values of the flexural *couples* is clearly unimportant,* so that we may write for the last equation

$$\frac{h^2\rho^2}{3}\frac{d^4w}{dx^4} + (1-\sigma^2)(w+\sigma_0\rho) = 0. \qquad (7)$$

The boundary conditions (5) and (6) give

$$\frac{d^2w}{dx^2} - \frac{\sigma}{\rho+w} = 0,$$

$$\frac{d}{dx}\left(\frac{d^2w}{dx^2} - \frac{\sigma}{\rho+w}\right) = 0,$$

or, by a similiar approximation,

$$\left.\begin{aligned} \frac{d^2w}{dx^2} - \frac{\sigma}{\rho} &= 0, \\ \frac{d^3w}{dx^3} &= 0, \end{aligned}\right\} \qquad (8)$$

Let us write for shortness

$$m^4 = \frac{3}{4}\frac{(1-\sigma^2)}{h^2\rho^2} \qquad (9)$$

The proper solution of (7) is then

$$w + \sigma_0\rho = A\cos mx\cosh mx + B\sin mx\sinh mx\,; \qquad (10)$$

and the conditions (3) to be satisfied at the edges $x = \pm b$ give

$$\left.\begin{aligned} -A\sin mb\sinh mb + B\cos mb\cosh mb &= \frac{\sigma}{m^2\rho} \\ A(\cos mb\sinh mb + \sin mb\cosh mb) & \\ + B(\sin mb\cosh mb & \\ - \cos mb\sinh mb) &= 0 \end{aligned}\right\} \qquad (11)$$

leading to

$$\left.\begin{aligned} A &= -\frac{\sigma}{m^2\rho}\cdot\frac{\sin mb\cosh mb - \cos mb\sinh mb}{\sinh 2mb + \sin 2mb} \\ B &= \frac{\sigma}{m^2\rho}\cdot\frac{\sin mb\cosh mb + \cos mb\sinh mb}{\sinh 2mb + \sin 2mb}. \end{aligned}\right\} \qquad (12)$$

The condition that $w = 0$ when $x = 0$ gives

$$\sigma_0\rho = A, \qquad (13)$$

and the value of w is thus completely determined.

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* This approximation may also be justified *a posteriori*. It will appear that the terms neglected are of the order h/ρ compared with those retained.

The distribution of applied force and couple over the ends (supposed straight) necessary to produce the strain in question is given by

$$P = \frac{8(\lambda+\mu)\mu}{\lambda+2\mu}(1-\sigma^2)h \, . \, \sigma_1$$

$$= \frac{2(3\lambda+2\mu)\mu}{\lambda+2\mu} h\left(\sigma_0 + \frac{w}{\rho}\right), \qquad (14)^*$$

$$G = \frac{8}{3}\frac{(\lambda+\mu)\mu}{\lambda+2\mu}h^3\left(\frac{1}{\rho} - \sigma\frac{d^2w}{dx^2}\right). \qquad (15)$$

This distribution is somewhat artificial, but the theory of "local perturbations" developed by St. Venant, Boussinesq, and others, warrants us in asserting that if it be replaced by any other distribution having the same force- and couple-resultants, the form assumed by the band will not be sensibly altered, except within a distance from the ends comparable with the breadth. It appears from (7) and (8) that

$$\int_{-b}^{b} P\,dx = 0, \qquad (16)$$

so that the forces on either end reduce to a couple

$$\int_{-b}^{b} G\,dx = \frac{8}{3}\frac{(\lambda+\mu)\mu}{\lambda+2\mu}h^3\left\{\frac{2b}{\rho} - 2\sigma\left(\frac{dw}{dx}\right)_{x=b}\right\}. \qquad (17)$$

On substitution from (10) and (12) this becomes, after a little simplification,

$$\int_{-b}^{b} G\,dx = \frac{8}{3}\frac{(\lambda+\mu)\mu}{\lambda+2\mu}h^3 . \frac{2b}{\rho}\left\{1 - \frac{\sigma^2}{mb}\frac{\cosh 2mb - \cos 2mb}{\sinh 2mb + \sin 2mb}\right\} \qquad (18)$$

The form assumed by the cross section of the band, and the value of the flexural couple, depend on the magnitude of mb, which is comparable with $b/\sqrt{(h\rho)}$. For sufficiently small curvatures, *i.e.* so long as ρ is large compared with b^2/h, mb is small, and we find without difficulty

$$w = \frac{\sigma}{2}\frac{x^2}{\rho}, \qquad (19)$$

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* Since $\sigma = \lambda/2(\lambda+\mu)$.

whilst the formula (18) for the flexural couple reduces to

$$\frac{4}{3}\frac{(3\lambda+2\mu)\mu}{\lambda+\mu}\frac{h^3 b}{\rho}, \qquad (20)$$

which is in fact the value given by the ordinary theory for a bar of breadth $2b$ and depth $2h$, the coefficient $(3\lambda+2\mu)\mu/(\lambda+\mu)$ being Young's modulus.

As the curvature increases beyond the limit above indicated, the flexural couple increases in a greater ratio, until in the other extreme, when ρ is small compared with b^2/h, and mb is consequently large, the expression for the couple becomes

$$\frac{16}{3}\frac{(\lambda+\mu)\mu}{\lambda+2\mu}\frac{h^3 b}{\rho} \qquad (21)^*$$

the same as for a *plate*. We have also in this case

$$\left.\begin{aligned} A &= \sqrt{2}\frac{\varrho}{m^2\rho}e^{-mb}\cos\left(mb+\frac{\pi}{4}\right) \\ B &= \sqrt{2}^2\frac{\varrho}{m^2\rho}e^{-mb}\sin\left(mb+\frac{\pi}{4}\right) \end{aligned}\right\} \qquad (22)$$

approximately, so that the value of w given by (10) and (13) is insensible except close to the edges. Near the edge $x=b$ we have, for example,

$$w=\frac{1}{\sqrt{2}}\frac{\sigma}{m^2\rho}e^{-m(b-x)}\cos\left\{m(b-x)+\frac{\pi}{4}\right\}. \qquad (23)$$

At the edge itself the deviation from the cylindrical form is comparable with h, but it rapidly diminishes as we pass inwards, at the same time fluctuating in sign. The latter result may perhaps be unexpected, but a little consideration will show that it is intimately bound up with the supposition we have made, that there is no resultant *force* on the ends of the band. The amplitudes of the fluctuations diminish, however, so rapidly that it is not likely that this feature of the strain could ever be made the subject of observation.

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* This exceeds the value (20), given by the ordinary theory, in the ratio $1/(1-\sigma^2)$.

Absorption Spectra, and a Method for their more Accurate Determination. By Alex. Hodgkinson, M.B., B.Sc.

(*Received March 18th, 1890.*)

When the various elementary bodies are raised to a sufficiently high temperature they glow with a light having qualities of such a special nature as readily to allow of the identification of such bodies from the nature of the emitted light. Examined by means of the spectroscope such light appears as the so-called radiation spectrum, which consists of the various rays of light constituting the original beam spread out into a series of bright lines, or bands, each of which occupies a constant and definite position in such spectrum in accordance with its special refrangibility.

Such is the uniformity in the constitution of the light emitted by the same substance, and such the identity in position which rays of the same refrangibility or wave frequency occupy in the spectrum, that this method of analysis, as applied to radiation spectra, is universally recognised as one of the most delicate methods of physical investigation. True it is that, with certain variations as regards temperature, pressure, and motion of the incandescent body, the position, number, and character of the spectral lines become materially modified; but these conditions are of an extreme and conspicuous nature, and, therefore, are unlikely to escape recognition or cause confusion whenever they may be present.

If half a dozen careful investigators were asked to supply wave length radiation spectra of any of the elementary bodies, even without specifying any conditions under which such investigation was to be conducted, the probability is that in their essential features such results would be almost identical.

Besides these spectra produced by the radiation of special kinds of light, another class of spectra exists to which the name of absorption spectra has been given, and since these constitute the subject of the present communication I shall, before considering the proposed method for their investigation, briefly allude to their nature and mode of formation.

Firstly, as regards absorption generally. All bodies are now recognised as being more or less pervious to light; and no substance is known which is absolutely transparent. Even the metals, regarded as the most opaque of bodies, when reduced to films of sufficient tenuity, become transparent to certain rays of light only, and, therefore, when seen by transmitted light appear coloured. Thus, gold appears greenish-blue; silver, blue; mercury, violet-blue; and so on. As such films become thinner, however, they transmit more and more light, until, as in the case of this gold film (exhibited) the transmitted light is almost colourless. Films produced in this way are, according to Faraday, "scarcely the $\frac{1}{100}$th, perhaps not the $\frac{1}{500}$th, of a wave undulation of light" in thickness. The reason why a body appears coloured when illuminated by white light is because certain rays have become absorbed, and the transmitted light, being deficient in these rays, is robbed of one of the essential elements for the formation of white light, namely a suitable admixture of variously coloured rays. When such coloured light is examined with the spectroscope, and the constituent rays thus spread out so as each to occupy its special position in the spectrum, the locality of the missing rays is indicated by a dark space, due to a deficiency of light at the spot. Such dark space constitutes a so-called absorption band, and a spectrum containing one or more of such absorption bands is known as an absorption spectrum. Thus, in the accompanying spectrum of blood (Plate I, Fig. 4) produced by allowing white light to pass through a thin layer of blood, we see two dark bands, one situated in the yellow and the other in the green, due to this special solution absorbing, or blotting out, the particular rays, which, if no coloured medium were there, would have appeared as yellow and green rays respectively. Such a spectrum is held, so far as spectroscopic analysis is concerned, as characteristic of the presence of oxyhæmoglobin, the colouring matter of arterial blood, and its essential features are the position and character of its absorption bands. The same remark applies to absorption spectra generally. *So far as spectroscopic examination is concerned* their analytic value is essentially dependent on the character and position of their absorption bands. Keeping this fact in view, the query "Are these characters constant for the same substances?" becomes a very important one. The variation in the nature of the light transmitted by a thick and a thinner film of gold will have prepared us for the answer, but unfortunately not for the whole cause of variation in the absorption spectra of the same bodies. Thus, Herr Vogel has shown (*Nature*, Vol. XIX., p. 495) that in some recorded instances the spectrum in the solid condition differs from that of the same substance in the liquid condition. That variation in the dissolving medium may, or may not, produce variation in the resulting spectra. Again, bands occupying exactly the same position were shown to characterise different bodies. After the above, which is merely a very brief epitome of some of this observer's strictures, a full account of which appears in the monthly report of the Berlin Academy of Sciences, the author naturally points out the importance of not placing too much reliance on spectroscopic analysis pure and simple, and lays stress on the advantage to be derived by observation of the spectra of media acted on by various reagents and solvents. "Thus, cyanine and aniline blue dissolved in alcohol give very similar spectra, dissolved in water totally different ones. The absorption bands of oxyhæmoglobin disappear with reducing agents, those of carmine, which are in a similar position, do not; the bands of braseline disappear when acetic acid is added to the solution, those of fuchsine do not, &c." Such facts as the above conclusively demonstrate the importance of exercising caution in drawing inferences from the mere spectroscopic appearance of bodies. With such an overwhelming array of objections to this method of analysis it might be supposed to be of little practical value. The contrary is, however, the truth. "The study of the absorption spectra of various physiological fluids," remarks MacMunn in his valuable work 'The Spectroscope in Medicine,' "has taught us more than their ordinary chemical analyses. More especially is this the case with blood; for not only has the spectroscope shown why arterial differs from venous blood in colour, but it also enables us to detect the minutest trace of blood; and also to understand how certain gases, &c., of a poisonous nature put an end to animal life." The observations of Kundt, Vogel, and others, showing the varying results obtained where no such variation was expected, merely point to the necessity of further observation to explain the apparent exceptions, and of improvement in the method of research, that our observations may be more reliable. Certainly no good can arise from under-estimating, as several observers do, the importance of the position of absorption bands in the spectrum. So far as spectroscopy is concerned this must ever constitute a fact of paramount importance, and I am convinced that whatever tends to ensure a more accurate determination of the relative position of absorption bands must tend to place absorption spectroscopy, as an accurate method of research, at a more measurable distance from radiation spectroscopy than can at present be claimed for it. If half-a-dozen careful investigators, without specifying conditions as regards quantity of substance used, &c., were asked to supply a wave-length spectrum of any absorption fluid or solid, the probability is that no two would be alike. And yet each might be accurate. The explanation of such discrepancy introduces yet another element of uncertainty in absorption spectroscopy, and that an important one, namely, the position and even the apparent existence of absorption bands vary with the amount of the absorbing medium. A glance at the accompanying diagrams (Plate I.) of the absorption spectra of human blood, serves to show the variation in the appearance of the spectrum when the light is made to pass through varying amounts of blood. In the upper spectrum, where the blood film is the thickest, no characteristic absorption bands are present; the same in the second; whilst in the third the true characteristic bands of oxyhæmoglobin are apparent. These continue to decrease in width, as the medium becomes thinner, until, in the lowest spectrum, there are no absorption bands apparent. Now, an observer, according to the thickness of blood film examined, would be justified in citing any of these spectra as that of blood. He would, of course, probably instance either the 3rd, 4th, 5th, or 6th; but the 1st and the 7th are also spectra of blood, for, though no absorption bands are perceptible in the lowest spectrum, the film, through which the light passes which forms it, is very perceptibly coloured when examined by the eye alone. I have cited blood as an example, because of its general importance; but the same is true of chlorophyll, bile, and in fact any absorbing fluids. The fact that the appearance of the resulting spectrum is dependent on the amount, or thickness, of the absorbing medium is of extreme importance, since quantity is a factor that is always present. To ensure a certain amount of uniformity in results, it is customary for the observer to use his discretion as to the amount of absorbing medium he employs, using such a quantity as will ensure the splitting up of any compound band into any smaller bands of which it may be constituted. But I need not say that such method must necessarily ensure very variable results, since, though each may have selected that thickness of absorbing medium necessary to ensure the separation of a compound band into its ultimate absorption bands, the *width* of these bands, or, what is the same thing, the position of these bands in the spectrum, is still a variable factor, being dependent on the amount or thickness of the absorbing medium. True, the results tend to become uniform as the thickness of the medium becomes less, and, if an infinitely thin film could be used, would be uniform; but the practical fact remains that all bodies become colourless long before such a point is reached, and, indeed, have to be of considerable thickness before any absorption is manifest by means of the spectroscope. And all practical observers know the difficulty of measuring faint absorption bands with ill-defined borders. It might be suggested that the central point of a band could be taken as an indication of its position in the spectrum, but against this is the fact that a band usually fades off more gradually on one side than on the other; in other words, that the point of greatest intensity of absorption is not in the centre of the band, so that, in selecting the central point, we should be giving preference to lines of less importance, so far as absorption is concerned. Such a method, therefore, would not help us. It is, moreover, impossible to secure any degree of accuracy by fixing a standard strength, or thickness, of the absorbing medium, although this is frequently suggested, since, in the great majority of instances, we do not know the percentage of colouring matter in the medium, and therefore equal thicknesses of such medium are not likely to represent equal amounts.

Seeing, therefore, that the spectrum of an absorbing body is so profoundly modified by the amount or thickness of the absorbing medium, and seeing that we are acquainted with no means of always securing the same amount of colouring matter for observation, it must be admitted that absorption spectroscopy can never compare with radiation spectroscopy, as a reliable means of investigation, so long as the recorded results of observation are influenced by this variable factor, the amount of the absorbing material. At one time it was hoped that by means of the spectroscope we might be able to distinguish the blood of one animal from that of another, and so render important service to medico-legal investigation by discriminating such blood stains, but, hitherto, no such result has been obtained, nor, with the present system, is it likely to be. The same applies to chlorophyll and other absorbing bodies.

Since, then, we cannot ensure constancy in the amount of absorbing medium, what is required is some method which shall give uniform results which are quite independent of such amount, and the object of my communication is to introduce to your notice such a method. In giving consideration to this subject it occurred to me, that, if we could by any means select that element of an absorption band which is common to *all* thickness of an absorbing medium, and record this primitive line only, instead of the variable broad band, we should have a recorded result which would, of course, be constant for all amounts of such medium. Now, since all media, if sufficiently thick, are opaque for all rays of light, therefore, the thinnest film of any medium must to some extent exert an absorbing effect on every ray of light, but not to the same extent, and it is therefore in this degree of absorption that we have our essential factor, and the question resolves itself into—What is the line of greatest absorption in any band? because this is the line of greatest absorption of any amount of material and independent of such amount. It is to this line I have applied the term "primitive absorption line," because it is the first to appear in a medium of gradually increasing thickness when light is passed through it. How then is such primitive line to be determined?

If we take a certain thickness of any absorbing body, say blood, and if such film is very thick, we get, when examined with the spectroscope, such a spectrum as is represented by Figure 1, Plate I.; the whole of the light is absorbed, excepting the red rays below D. As the film is made thinner, a broad absorption band is distinguished extending from a little above D to E, and, by reducing the thickness still more, this broad band is resolved into the two characteristic absorption bands of oxygenated or arterial blood. If we trace either of these bands down through successively thinner films, we find they become narrower and fainter until they become invisible, and, therefore, in spectrum (7) we have no absorption band depicted. This fading away of the band occurs long before the edges of the same band join each other, or the band becomes a mere line.

If, now, I take a hollow prism, carefully made of very thin glass, and, having filled it with a solution of blood, place it before the slit of the spectroscope with the refracting angle of the hollow prism at right angles to the long axis of the slit, when looked at through the slit only, the prisms of the instrument being temporally removed to allow of this, it presents the appearance seen at (1) Plate II. At the base of the hollow prism, where the light has to pass through a great amount of absorbing fluid, the slit appears of a dark red, whilst, as we approach the apex of the prism the slit appears lighter and lighter, until at the apex, which is marked on the diagram as the "central line," it appears almost colourless. If, now, the light from this slit is allowed to pass through the prism of the spectroscope, we observe the appearance depicted in the adjacent Figure 2.

Here we have a continuous representation of what was represented in interrupted stages in Plate I. And this, I may remark, is not a mere diagrammatic representation of what is seen, but a representation carefully measured and drawn to scale of the appearance as seen through one of Zeiss's micro-spectroscopes. We notice that both absorption bands are uniformly wedge-shaped, the broad ends of the wedges corresponding to the darkest end of the slit. On tracing each absorption band downwards, its edges are seen to converge uniformly, until, when at a point in about the middle of the figure, and long before the edges have come together, the band becomes *invisible.* If, now, bearing in mind that the convergence of the sides of the band is uniform, the lower half of this band A is temporarily obscured from view, we can correctly infer its position by continuing the two sides of the upper, or unobscured, portion of the band in the same lines, respectively, downwards: and the same may be done in the case of the *invisible* portion, and so *its* position be inferred, though we cannot see it. On doing so we shall find that they converge in this instance to a point at ·578 on this scale of wave lengths, which is a scale reflected from the surface of the spectroscopic prism. This point of convergence is in the line of greatest intensity, or the absorption line which first appears in the thinnest film, and, therefore, a line essential to all thicknesses of this medium. And this is what we were looking for. On dealing with the other absorption band at B, the lines drawn along the sides of the band converge to a point below the scale, and on drawing a line at right angles to the scale and through the point of convergence it is found to cut the scale at ·542. Constructing a spectrum with these two primitive lines in position, we get such a one as is depicted at (3) indicated as "the primitive spectrum of human arterial blood." For purposes of comparison with other and similar spectra, such a spectrum as this, assuming its correctness, with its absorption bands narrow and defined as the lines of a radiation spectrum, admits of much more accurate results being attained than is possible with the broad banded, indefinite spectrum obtained in the ordinary way.

Having shown how the absorption line of maximum intensity may be obtained from these converging absorption bands, and the position of such primitive line be indicated on the spectroscopic scale, we require to know, firstly, whether the positions of these primitive lines are constant whatever the strength of the absorbing solution, and, secondly, whether they are constant if the angle of the wedge-shaped cell is varied ; since each of these conditions produces a profound modification in the appearance of the spectra.

Firstly, then, what is the effect of varying the strength of the solution in the same hollow prism? To ascertain this I carefully constructed a small hollow prism with a refracting angle of 34°40′. This was placed in front of the spectroscopic slit, with its refracting edge at right angles to the slit and so arranged that it could be moved up and down, so that its edge could be made to cross the slit at any point required. The spectrometer employed on this occasion, one specially made for me by Hilger, of London, is furnished with one whole and two half prisms of calcite, and is graduated to 5′ of arc reading by means of a vernier to single minutes. Its dispersive power is, therefore, considerable, and its mechanical construction is very good. It is, in fact, a twin instrument to the one with which Messrs. Liveing and Dewar have done such good work. Arranging the wedge-shaped cell, full of a *strong* solution of blood, in front of the slit, the spectrum was observed in the usual way, excepting that the eye-piece of the spectrometer consisted of a filar micrometer, so arranged that the cross webs moved up and down *in the axis of the slit*, so that the decussation of the webs might be raised to any level from apex to base of the band, and thus allow of the band being accurately measured *in its length.* Its width was measured in the usual way by the scale which indicates the angular position of the observing telescope. A chart was next constructed, having the dispersion scale of the instrument reduced to wave lengths along the upper margin and the readings of the micrometer along the side, as depicted in Plates III., IV., and V. With the various readings on which the measurements and positions of these bands on the chart depend, I need not trouble you, suffice it to say that on shading the spaces bounded by the series of measured points respectively constituting the sides of these bands, the representations depicted in Plates III., IV., and V. were obtained. My instrument was good, and the measurements carefully made, and they may be safely accepted as of very considerable accuracy. We may, therefore, treat the representation as if it were the phenomenon itself. On drawing lines along the sides of the band marked A, in Plate III., they converge to a point below the scale, and on drawing a line at right angles to the scale it cuts it at λ ·571. The band B, treated in the same way, gives a primitive line at λ ·540. These results are recorded in the primitive spectrum, placed for purpose of comparison and convenience of construction below the above spectrum.

Some of the blood solution was next removed from the hollow prism, about two-thirds, and the prism filled up with distilled water. A considerably diluted solution was thus obtained. On observing the spectrum, the result represented in Plate IV. was seen, and recorded on a similar chart in the same way as in the previous case. In appearance generally, and in the form of the absorption bands, considerable alteration is apparent. On ascertaining the position of the primitive lines, A is found to occupy a position on the scale at λ ·573 and B at λ ·542. It will be observed that the difference is only in the third decimal place, and not a great one there. The variation in strength of the absorbing medium, therefore, exerts little, if any, effect on the position of the lines in the primitive spectrum.

To complete the enquiry, it remains to determine whether, or not, a variation in the angle of the hollow prism exerts any effect on the position of the primitive lines. For the purpose of deciding this, I constructed a prism with a refracting angle of 30°5′. The spectrum depicted in Plate V. was obtained, and the primitive spectrum seen beneath determined. The line A is at λ ·576, and B at λ ·543. Again, the variation is only in the third decimal place, and not a great one. It may be objected that a difference in the angle of the hollow prism of 4° 35′ is not a great one, but the spectrum represented in Plate III. is that of pure blood, observed in a prism of not more than 10°, and the variation here is still only in the third decimal place. We are, therefore, justified in saying that the variation in the angle of the hollow prism exerts little or no effect on the position of the absorption lines of the primitive spectrum.

That a fair idea may be obtained of the uniformity of these results, on Plate VI. the four primitive spectra obtained as described are arranged in series under the same scale. A fifth spectrum is added, which is a spectrum obtained by taking the mean position of the lines in the other four. This I regard as, within very narrow limits, the true primitive spectrum of oxyhæmoglobin.

It may here be pertinently enquired what the variation, slight though it is, is due to. I believe such variation to be due to two causes. Firstly, the having no special appliance in the eye-piece of the spectroscope, to arrange along the edges of the absorption bands so as to accurately indicate their points of convergence. Secondly, some probable inequality in my hollow prisms, which were home-made. The first want necessitated the graphic mode of representation constituting the diagrams, and there is sure to be some error in their construction, and, since the position of the absorption bands represented in Plates II., III., IV., and V. were determined from them, and the primitive lines from these, such error would affect the result. In Plate VI. the primitive spectra of arterial blood (human), obtained by examining wedge-shaped portions of the medium under the most extreme conditions of variation as regards strength, angle of prism, dispersion, and instrumental conditions, are represented together under the same dispersion scale. From this it is seen how close the agreement is, in the most extreme instance, the variation being in the third decimal place only, whilst in other instances they are identical, or almost so. With special arrangements for indicating the position of the edges of the bands, and more perfect forms of wedge-shaped absorption cells, I believe the results would be still more uniform.

In order therefore to remove these sources of error, and also to facilitate this mode of observing, I am having constructed, and hope on a future occasion to bring before your notice, the following two simple appliances :—

Filar Eye-piece. This is an eye-piece with a circular disc of glass fixed in the focus of the eye-lens. A vertical line is ruled through its centre, and at right angles to this, at a distance of one-third from its lower end, a transverse line, which is divided by a series of fine vertical lines. A pair of webs, moveable, so as to allow of their being laid along the edge of an absorption band, completes the arrangement. The appearance seen on looking through the eye-piece of the spectroscope is depicted in Plate VII., Fig. 1, arranged for centring the telescope on the primitive line of a converging or wedge-shaped band. Extending from the upper edge at A, through the centre to the lower edge at B, is the vertical line. From the lateral edge at C, and cutting the vertical line a little below its centre and extended to D, is the transverse line, which is seen divided by vertical lines into a series of equal parts. The shaded portion E represents the wedge-shaped absorption band, the primitive absorption line of which it is intended to "centre" so as to ascertain its position on the scale of the spectroscope. Having moved the telescope of the instrument so that the vertical line A, B, is approximately in the centre of the absorption band, it is next necessary to determine the point of convergence of the sides or edges of the absorption band. Before doing this, it is advisable to arrange the hollow prism containing the absorbing medium so that its refracting edge occupies a position as regards the ends of the slit, say, on a level with the transverse line, as is the case in all the foregoing examples. One portion, F (the lower), of the observed spectrum is that of the medium, the other portion, G (the upper),* the unobscured spectrum of whatever light source may be employed. For indicating the point of convergence of the band, the eye-piece is provided with two webs, or wires, HB, IB, which are freely moveable in the focal plane, so that they may be arranged along the edges of the absorption band. In the case of faint indefinite bands, lines of as equal degrees of absorption as possible on either side of the band are selected. Since, moreover, towards the apices of the bands the converging sides become curved, it is advisable to take the line of convergence from the base of the wedge-shaped bands, where absorption is more definite and each side apparently a right line. The webs, or wires, being in position along the edges of the band, they converge probably to a point situated to one or other side of the central line A, B. Say this is four divisions of the divided transverse line to the right of the central line. The value of these divisions in terms of the scale of the spectroscope being known, this is allowed for, and so the correct position is readily deter-

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*The terms "upper" and "lower" here used refer to the *apparent* upper and lower halves, the object appearing reversed by the instrument.

mined. To take an example, a wedge-shaped band is roughly centred so that the position of the vertical line lies somewhere about its centre. In observing the position of the observing telescope on the spectroscopic scale, it is seen to be 180°. The convergence of the sides of the band are next indicated with the moveable webs, and found to meet at a point two divisions of the transverse line *above* (*i.e.*, towards the violet) the central vertical line. Each division of the line is found to equal 30′ of arc. This must, therefore, be added to 180°, giving 181° as the correct reading of the primitive line on the spectroscopic scale. This can be reduced to wave-lengths by means of an interpolation curve or formula. Such is the method to be adopted with large instruments, and when great accuracy is needful. Where the spectroscopic scale is reflected from the surface of the nearest prism, and such scale is a wave-length scale, which is to be recommended for ordinary purposes, the method becomes much more expeditious, since in such instances the point of convergence of the sides of the bands is directly indicated on the scale. Even without wires, or webs, a rough idea may be formed, at a glance, of the point on the scale to which the sides converge. Such method is often useful in the case of the micro-spectroscope.

Wedge-shaped Cells. An exceedingly expeditious method of obtaining a wedge-shaped portion of absorption fluid is by simply placing a minute drop of the fluid to be examined on an ordinary microscopic slide, and placing on this drop a plano-convex lens of short radius of curvature. If the front lens (A) of an ordinary achromatic condenser, Fig. 1, Plate VIII., be removed, a drop of the fluid, say blood, (*b*) may be placed on the upper surface of the subjacent lens (B), and, replacing the upper lens, it may be screwed down so as nearly to touch the surface of the one beneath, and thus a plano-concave film of the absorption fluid is formed, any radial section of which constitutes a wedge. For obvious reasons this is only useful for very opaque fluids, where, in fact, the position of the wedge to be examined is near the centre of the lens. Such a form of cell I have termed a "lenticular cell." The appearance presented on looking through the upper lens at small quantities of blood and chlorophyll, respectively, arranged for examination according to the above method, is represented by Figures 2 and 3, Plate VII.

A more generally useful form of absorption cell is the "conical absorption cell," which possesses the advantage of forming a fluid wedge, or prism, available from centre to periphery, and thus adapted for use with fluids of considerable opacity, as well as those of a more transparent character. The diagram, Fig. 2, Plate VIII., is a representation of this form of cell. The cone A 'which is constructed with its angle of 90°,' is composed of crown-glass of very low refractive density, so as to approach as nearly as possible to that of water, the common solvent of most absorptive media. By this arrangement the cell is made compensating, the refraction of the cone correcting that of the medium. In such a cell the thickness of the medium is equal to its distance from the apex of the cone. Where it is desirable to pass the light transmitted through the absorption media of the cell in a horizontal direction, as in the case where used with many forms of spectroscopes, this can be effected by means of a rectangular prism on the upper surface of the cone, another rectangular prism being connected below the glass plate B, so as to reflect the light horizontally through the slit of the instrument.

Hymenoptera Orientalis, or Contributions to a knowledge of the Hymenoptera of the Oriental Zoological Region. By P. Cameron. Communicated by John Boyd, Esq.

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PART II.

NYSSONIDÆ.

GORYTES.

I. *Eyes not converging beneath.*

(*a*) *Anal nervure received distinctly before the origin of the cubital nervure in the posterior wings.*

1. GORYTES ORNATUS.

Gorytes ornatus, Smith, *Cat. Hym.* IV., 371, 5,[1] Handlirsch, *Sitz. d. Kais. Akad., Wien*, XCVII., 443, 58.[2]

Northern India,[1] Burmah.[2]

Unknown to me.

(*b*) *Anal nervure received after the origin of the cubital in the hinder wing.*

2. GORYTES ORIENTALIS (Plate IX., fig. 14 head, 14[a] antenna).

Gorytes tricolor, Smith, *Trans. Ent. Soc.*, 1875, 40. (Nec. Cresson.)

Gorytes orientalis, Handlirsch, *Sitz. d. Kais. Akad., Wien*, XCVII., 5, 57, 114.

A very variable species, especially as regards the amount of black, red, and yellow on the head and thorax. The eyes are almost parallel, of moderate size, reaching a little below the base of the clypeus and with moderately large facets; the antennæ with the ♀ stout, thickened towards the apex; the third joint about one-fourth longer than the fourth;

in the ♂ nearly the same relative length and with joints 10—13 hollowed beneath. There is a longitudinal keel on the mesosternum, and there are two perpendicular and one wider and shorter oblique furrows on the mesopleuræ. The first and second transverse cubital nervures are curved; the second cubital cellule at the top is somewhat less than the space bounded by the two recurrent nervures. In the hind wings the anal nervure is received shortly behind the origin of the cubital nervure. The head and thorax bear scattered punctures, those on the head being finer than those on the thorax. The basal area of the median segment is clearly limited by a crenulated furrow; it is broader than long; has two central keels, united by transverse bars; and there are five stout keels on either side of these. The apex of the median segment is hollowed in the centre, and transversely striolated. The basal area varies from black to red. The petiole is moderately broad at the base, and becomes gradually broader towards the apex. Fore tarsi stoutly spined.

Barrackpore (*Rothney*). Several specimens.

3. GORYTES PICTUS.

Gorytes pictus, Smith, *Cat. Hym. Ins.* IV., 365, 22; Handlirsch, *Sitz. d. Kais. Akad. d. Wissen., Wien*, XCVII., 537.

I suspect that this is only a variety of *Orientalis*; but inasmuch as Smith's description gives no information as to what group *G. pictus* belongs, this can only be decided by an examination of the type.

Hab. Madras.

II. *Eyes converging beneath.*

4. GORYTES AMATORIUS (Pl. IX., Fig. 15 head 15a antenna).

Gorytes amatorius, Smith, *Trans. Ent. Soc.*, 1875, 39;[1] Handlirsch, *Sitz. d. Kais. Akad. d. Wiss., Wien*, XCVII., 536.

Antennae subclavate, the flagellum thin at the base; the third joint more than twice the length of the fourth. Eyes large, reaching to the base of the mandibles, distinctly converging there, and coarsely facetted. Ocelli almost forming a triangle; separated from each other by twice the length that the posterior are from the eyes. Clypeus moderately convex, the apex margined, almost transverse. Mesosternum without a keel. Basal area of the median segment smooth, shining, glabrous, and limited by a narrow indistinct furrow. Petiole nodose, clearly defined from the second segment, which, at the extreme base, is equal in breadth to it, but from there it becomes much wider. Abdomen elongate, longer than the head and thorax united. Pygidial area clearly limited, covered with short, depressed, coarse, bristle-like hairs, and apparently longitudinally striolated; the sides margined. The second cubital cellule at the top is not very much shorter than the third; and more than the length bounded by the recurrent nervures; the first transverse cubital nervure is angled, near the middle. Fore tarsi and tibiæ spinose.

Barrackpore[1] (*Rothney*). Bombay (*Wroughton*).

NYSSON.

Of the 64 described species of this widely known genus, only two have hitherto been recorded from our region.

1. NYSSON BASALIS.

Nysson basalis, Smith, *Cat. Hym. Ins.* IV., 355, 11;[1] Handlirsch, *Sitz. d. Kais. Akad. d. Wissen.*, XCVII., 401.

Hab. India.[1]

2. NYSSON DORIAE.

Nysson Doriæ, Gribodo, *Bull. Soc. Ent. Ital.* XVI. 277,[1] Handlirsch, *l. c.*

Hab. Sarawak. Borneo.[1]

3. Nysson rugosus (Pl. IX., Fig. 13 head, 13^a antenna)
Niger, linea pronoti, linea abdominis segmentibus 1—2, *maculaque scutelli, flavis, abdominis basi femoribusque posticis rufis ; alis fuscis.* Long. 5—7 mm.

Antennæ stout, covered with a white microscopic pile ; the third joint not much longer than the fourth ; the last conical at apex, longer than the preceding. Head strongly punctured ; densely covered with silvery, inclining to golden on the vertex, pubescence. Cheeks margined ; an elongated wedge-shaped projection on the front, immediately above the antennæ ; eyes slightly sinuated above ; apex of clypeus bi-dentate in the middle. Mandibules yellow at base, rufous at the apex. Thorax rugosely punctured, covered with a whitish pubescence ; pronotum slightly raised in the middle above, the centre shining, impunctate, glabrous ; the sides, looked at from above, curved. Scutellum much more strongly rugose than the mesonotum ; metanotum not very clearly defined from it, rounded and narrowed behind ; median segment aciculate, shining, bearing four keels ; the lateral angles acute, the spine stout, longer than broad. Mesopleuræ convex, densely pilose, strongly punctured, clearly projecting beyond the metapleuræ. Abdomen sparsely covered with shallow distinctly separated punctures, the apical two segments more strongly than the others ; pygidial area longitudinally rugosely punctured. Ventral segments punctured like the dorsal ; the basal margined laterally ; broadly projecting in the middle ; the centre of the projection stoutly bicarinate, and its sides are also keeled. Hypopygium aciculate at base and in the centre ; the rest punctured, the apex bluntly bi-denticulate. The basal abdominal segment is entirely red, except a yellow line at the apex ; the apex of the second segment is yellow ; the third at the base is more or less red ; the basal two ventral segments are red. Legs (especially the tibiæ and tarsi) densely covered with whitish pile; lateral edges of the coxæ, the knees and apices of the tibiæ more or less yellowish; the hind femora entirely, and the four anterior more or less underneath, rufous; the hind tibiæ more or less rufous beneath. The second cubital cellule is longly pedunculated; the second recurrent nervure is almost interstitial; tegulæ red.

The tibiæ are not spined, nor the clypeus keeled; the metanotum is not bilobate. In some specimens there is a small yellow mark on the sides of the third and fourth abdominal segments.

Hab. Barrackpore (*Rothney*).

4. NYSSON ERYTHROPODA, *sp. nov.* (Pl. IX., Fig. head 18, 18^a antenna).

Niger, argenteo pilosus, capite et thorace rugoso-punctatis; antennis subtus pedibusque rufis, linea pronoti, tegulis, linea scutelli maculisque abdominis segmentis 1—2 flavis; alis fuscis. Long. 6·5 mm.

Agrees closely with *rugosus*; differs in having the antennæ rufous beneath, the legs entirely red, except the base of the coxæ; the base of the abdomen is not red; the yellow line on the pronotum is continuous; the basal joint of the antennæ is more globular, thicker, and shorter; the second is not much shorter than the third; the eyes are more curved, the ocelli more raised; the mesopleuræ at its hinder edge has a stout keel interrupted in the middle, and prolonged beneath near to the sternal groove; the hypopygium is more sharply convex in the middle; the second cubital cellule is longer, being as long, on the lower side, as the third, whereas in *rugosus* it is clearly shorter.

The clypeus is bi-dentate at the apex; the mandibles and palpi obscure rufous; there are four keels on the median segment; its sides are densely covered with pale pubescence; its spine is blunt; the white pile on the tibiæ is very dense, almost hiding the color.

Hab. Barrackpore.

BEMBICIDÆ.

STIZUS.

1. STIZUS BLANDINUS.
Larra blandina, Smith, *Cat. Hym. Ins.* IV., 346.[1]
Hab. India.[1]

2. STIZUS CORNUTUS.
Larra cornuta, Smith, *Ann. Mag. Nat. Hist.*, 1873, p. 403.[1]
Hab. Bombay.[1]

3. STIZUS DELESSERTII.
Stizus Delesserti, Guérin, *Icon. Règ. Anim.* III., 439.
Larra Delesserti, Smith, *Cat. Hym. Ins.* IV., 342.[1]
Hab. Pondicherry.[1]

4. STIZUS FASCIATUS.
Larra fasciata, Fab., *Ent. Syst. Supp.* 253; *Syst. Piez.*, 221, 13; Klug, *Symb. Phys, Dec.* V. t. 46 f. 14? Smith, *Cat. Hym. Ins.* IV., 342.[1]
Stizus fasciatus, Dahlbom, *Hym. Eur.* I., 133.
Hab. Barrackpore, Tranquebar,[1] Northern India,[1] Ethiopia.[1]

5. STIZUS MELANOXANTHA.
Larra melanoxantha , Smith, *Cat. Hym. Ins.* IV., 346.[1]
Hab. India.[1]

6. STIZUS MELLEUS.
Larra mellea, Smith, *Cat. Hym. Ins.* IV., 346.[1]
Hab. India.[1]

7. STIZUS NUBILIPENNIS.
Larra nubilipennis, Smith, *Cat. Hym. Ins.* IV., 347.[1]
Hab. India.[1]

8. STIZUS PRISMATICUS.
Larra prismatica, Smith, *Jour. Linn. Soc.*, 1857, 103, 1.[1]
Stizus prismaticus., Sichel, *Hym. d. Novara Reise*, 142.[2]
Hab. Borneo;[1] Sambelong.[2]

9. STIZUS REVERSUS.
   Larra reversa, Smith, *Cat. Hym. Ins.* IV., 349.
   Hab. Sumatra.[1]

10. STIZUS RUFESCENS.
   Larra rufescens, Smith, *Cat. Hym. Ins.* IV., 349.

11. STIZUS ORIENTALIS, Cam., *infra.*
   Hab. Barrackpore.

12. STIZUS VESPIFORMIS.
   Sphex vespiformis, Fab., *Spec. Ins.* I., 447, 23.
   Tiphia vespiformis, Fab., *Mant. Ins.* I., 1781.
   Larra vespiformis, Fab., *Ent. Syst.* II., 220, 1,; *Syst. Piez.*, 219, 1.
   Stizus vespiformis, Dahlbom, *Hym. Eur.* I., 154; St.-Fargeau, *Nat. Hist. Hym. Ins.*, III., 297.
   Hab. Madras, Punjaub, Northern India.

STIZUS ORIENTALIS, *sp. nov.*

Brunneus, flavo-variegatus, facie flava; antennis pedibusque rufis; alis flavo-hyalinis. ♀ Long. 24 mm.

Eyes converging towards the apex; ocelli in a triangle; the anterior in a pit; the posterior separated from each other by almost twice the distance they are from the eyes; a broad furrow runs down from the anterior. Clypeus convex; labrum rounded broadly at the apex. A dark brownish stripe runs through the hinder ocelli to the eyes; the anterior ocellus has a similar brownish spot; and there is an elongated mark over each antennæ. The head is closely and finely rugosely punctured. Mandibles clear yellow at the base, shining, impunctate; palish yellow. Scape punctured, covered with a short silvery pile; the third joint is as long as the fourth and fifth united. Thorax finely rugosely punctured; densely covered with soft woolly white hair; median segment at apex semi-perpendicular, deeply and widely sulcated, and transversely striated. The pronotum above and laterally, and the tubercles are yellowish; the mesonotum in front narrowly and more or less of the mesopleuræ are blackish; the apex of median segment also inclining to blackish. Abdomen minutely punctured; a large ovate macula on the sides of the second segment; the greater part of the third and fourth, and the edges of the fifth, clear yellow; the third and fourth ventral segments broadly clear yellow at the sides. Pygidial area punctured. The second cubital cellule is very narrow at the top, not being much more than half the length of the part bounded by the recurrent nervures, and a little more than the space between the second recurrent and the second transverse cubital nervures; the first recurrent nervure is received a little beyond the middle of the cellule. Legs with the tibiæ and tarsi densely covered with a microscopic white pile and stoutly spinose.

STIZUS RUFESCENS, Smith.

A specimen from Barrackpore is no doubt this species—at least it agrees with Smith's description so far as it goes. It is very closely allied to *S. orientalis*; from which, apart from the difference in the coloration of the body, it may be known by the eyes being wider separated, and not, or hardly, converging towards the clypeus; the ocelli are more widely separated from the eyes, and not so much from each other; the radial and second and third cubital cellules are occupied by a deep black cloud: the second cubital cellule is wider at the top: the first recurrent nervure is received before the middle: the apex of the median segment is not so deeply or so widely sulcated; and the wings have a much more yellowish tinge, the nervures and base of stigma being lighter, almost rufous. The length of my specimen is fully one inch.

STIZUS REVERSUS, *Smith.* (Pl. X. f. 1 antenna ♂.)

This species (it is named by Smith in Mr. Rothney's collection) is common and widely distributed. It shows some variation in the quantity of yellow on the abdomen, as do also the legs, some examples having the tibiæ and tarsi entirely yellow.

BEMBEX.

Of this well-known genus, only four species are known from our region.

1. BEMBEX LUNATA.

Fabricius, *Syst. Piez.*, 224, 10; Dahlbom, *Hym. Eur.* I, 492, 33; Smith, *Cat. Hym. Inst.* IV, 328, 44.[1]

Hab. Tranquebar,[1] Tirhoot (*Rothney*), Bombay (*Wroughton*).

Seemingly the rarest of the species.

2. BEMBEX TREPANDA.

Dahlbom, *Hym. Eur.* I., 181; Smith, *Jour. Linn. Soc.*, 1869, 366.[1]

Hab. Barrackpore (*Rothney*); Bombay (*Wroughton*); Gilgit (*Mus. Cal.*); Ceylon (*Rothney*), Celebes,[1] Gilolo.[1]

3. BEMBEX SULPHURESCENS.

Dahlbom, *Hym. Eur.* I, 180; Smith, *Jour. Linn. Soc.*, 1869, 328.

Hab. Barrackpore, Tirhoot, Madras (*Rothney*), Punjaub.[1]

4. BEMBEX MELANCHOLICA.

Smith, *Cat. Hym. Ins.*, IV., 328.[1]

Hab. China, Sumatra, Borneo, Singapore, Bachian, Celebes, Aru, Salwatty, Morty Islands.[1]

Said by Wallace (*Jour. Linn. Soc.*, 1869, 296) to be common in sandy situations all over the Malay Archipelago.

PHILANTHIDÆ.

PHILANTHUS.

I have only seen one Indian species of this genus, but Smith records six.

1. PHILANTHUS ELEGANS.
Smith, *Ann. Mag. Nat. Hist.* XII., 415.
Hab. Northern India.

2. PHILANTHUS NOTATULLUS.
Smith, *Proc. Linn. Soc.* V., 157.[1]
Hab. Menado.[1]

3. PHILANTHUS PULCHERRIMUS.
Smith, *Cat. Hym. Ins.* IV., 469, 5.[1]
Hab. India.[1]

4. PHILANTHUS SULPHUREUS.
Smith, *l. c.* 469.[1]
Hab. North India.[1]

5. PHILANTHUS DEPREDATOR.
Smith, *l. c.* 470.[1]
Hab. India,[1] Barrackpore (*Rothney*).

6. PHILANTHUS BASALIS.
Smith, *l. c.* 473.[1]
Hab. Ceylon.[1]

CERCERIS.

1. CERCERIS ALBOPICTA, Smith, *Ann. Mag. Nat. Hist.* XII, 412.[1]
Hab. Bombay.[1]

2. CERCERIS BIFASCIATA, Guér., *Icon. Règ. An.* 443, Taf. LXXI. f. 9.[1]
Hab. Bengal.[1]

3. CERCERIS DENTATA, Cam. *postea.*
Hab. Barrackpore (*Rothney*), Poona (*Wroughton*).

4. CERCERIS EMORTALIS, Saussure, *Reise Novara, Hym.*, 98.[1] (See *C. humbertiana.*)
Hab. Ceylon.[1]

5. CERCERIS FEROX, Smith, *Cat. Hym. Ins.* IV., 454.[1]
Hab. Sumatra.[1]

6. CERCERIS FERVENS, Smith, *Ann. Mag. Nat. Hist.* XII. 411.[1] (See *postea*).
Hab. North India.[1]

7. CERCERIS DISSECTA, Fab.
PHILANTHUS DISSECTUS, Fab., *Ent. Syst. Supp.* 269.[1]
Hab. India.[1]

8. CERCERIS FLAVOPICTA, Smith, *Cat. Hym. Ins.* IV., 451.
Hab. North India, Barrackpore, Tirhoot, Madras (*Rothney*).

9. CERCERIS HILARIS, Smith. *Cat. Hym. Ins.* IV., 452.[1]
Hab. North India,[1] Madras (*Rothney*).

10. CERCERIS HUMBERTIANA, Saussure, *Hym. d. Novara Reise*, 97.
Cerceris rufinodis, Smith, *Trans. Ent. Soc.*, 1875, p. 41.
Cerceris viscosus, Smith, *Trans. Ent. Soc.*,[1] 875, 40.
Hab. Ceylon, Barrackpore.

11. CERCERIS INSTABILIS, Smith, *Cat. Hym. Ins.* IV., 452 ;[1] Saussure, *Hym. d. Novara Reise*, 92.[2]
Cerceris velox, Smith, *Trans. Ent. Soc.*, 1875, 41.
Hab. China; Barrackpore (*Rothney*), Poona (*Wroughton*), Ceylon.[2]

12. CERCERIS INTERSTINCTA, Fabricius.
Philanthus interstinctus, Fab., *Ent. Syst. Supp.*, 269 ; *Syst. Piez.*, 306.[1]
Hab. India.[1]

13. CERCERIS MASTOGASTER, Smith, *Cat. Hym. Ins.* IV., 453.[1]
Hab. Madras.[1]

14. CERCERIS NOVARÆ, Saussure, *Hym. d. Novara Reise*, 92, Taf. IV., f. 54.[1]
Hab. Ceylon,[1] Bombay, Barrackpore (*Rothney*), Poona (*Wroughton*).

15. CERCERIS NEBULOSA, Cam. *postea.*
Hab. North Khasi (*Goodwin-Austin*).

16. CERCERIS ORIENTALIS, Smith, *Cat. Hym. Ins.* IV., 54.
Hab. Madras,[1] Barrackpore.

17. CERCERIS PENTADONTA, Cam. *postea.*
Hab. Barrackpore (*Rothney*).

18. CERCERIS PICTIVENTRIS, Dahlbom, *Hym. Eur.* I., 498.[2]
Cerceris pictiventris, Guerstacker, *Monatsch. Berl. Akad. d. Wiss.*, 509; Peters, *Reis. Mozambique*, V., 474.[1]
Hab. West Africa,[1] Java.[2]

19. CERCERIS PULCHRA, Cam. *postea.*
Barrackpore (*Rothney*), common, Poona (*Wroughton*).

20. CERCERIS ROTHNEYI, Cam., *postea.*
Hab. Barrackpore (*Rothney*).

21. CERCERIS SEPULCRALIS, Smith, *Proc. Linn. Soc.* II., 107.[1]
Hab. Borneo.[1]

22. CERCERIS SULPHUREA, Cam. *postea.*
Hab. Bombay (*Rothney*).

23. CERCERIS TRISTIS, Cam. *postea.*
Hab. Barrackpore, Tirhoot (*Rothney*). Common.

24. CERCERIS TETRADONTA, Cam. *postea.*
Hab. Poona (*Wroughton*).

25. CERCERIS VIGILANS, Smith, *Cat. Hym. Ins.*, IV., 454.
Hab. Madras,[1] Barrackpore (*Rothney*). Common; Poona (*Wroughton*).

26. CERCERIS VISCHNU, Cam. *postea.*
Hab. Barrackpore (*Rothney*), Poona (*Wroughton*).

A. *Clypeus in ♀ not porret.*

Cerceris viligans, Smith (Pl. X., f. 2, *a*, *b*).

The ♂ only is described by Smith. The ♀ has the clypeus convex, ending in a rounded point before the apex, from which point it goes obliquely to the labrum, ending on either side in a blunt tooth, the teeth forming with the apical point a triangle. Eyes almost parallel. Ocelli not forming a triangle, the hinder separated from the eyes by the length of the second and third antennal joints united; and from each other by not very much more than the length of the second joint. The third antennal joint is fully one half longer than the fourth, and not much shorter than the first. There is a short blunt triangular tooth on the hinder edge of the mesosternum. The punctuation of the head is moderate; on the thorax much coarser and rugose; the metanotum is rugose; the triangular area on the median segment is large, transversely striated, and indistinctly furrowed down the middle. The pygidial area is opaque, irregularly punctured; twice broader at the base than at the apex, the contraction taking place beyond the middle; the apex rounded, the sides punctured, the hair fringe long, dense, and fulvous. Hypopygium finely punctured, opaque; the incision triangular, reaching a very little beyond the middle.

In the ♂ the clypeus is equally convex, bluntly keeled in the middle, the apex broadly rounded; the triangular area on the median segment is longitudinally striolate, the striæ wide apart; the pygidial area is of equal width and is punctured irregularly.

In both sexes the petiole is wider than long, sparsely punctured; the sculpture on the other segments is weak and becomes almost obsolete on the fifth segment.

CERCERIS ROTHNEYI, *sp. nov.* (Pl. X., f. 3, *a*, *b*).

Ferruginous, the vertex for the greater part black; the fourth and apical segments of abdomen dark piceous; the scape beneath, the cheeks, clypeus, basal half of mandibles, tegulæ, a line on the pronotum, tubercles, scutellum, metanotum, the base of second abdominal segment, the third segment, except on semi-circular space at the base, the fifth segment, the basal two ventral segments and the penultimate on either side and the legs, yellow ; the femora lined with fuscous above. Wings clear hyaline, the apex infuscated, the stigma and nervures fuscous. Body covered closely with whitish pubescence, which is especially thick on the head. The punctuation of moderate intensity ; the trigonal area of median segment smooth, impunctate, and there is an impunctate space on the sides of the median segment and on the metapleura. Clypeus moderately convex, the apex transverse, with a short blunt tooth at either end. Hinder ocelli separated from the eyes by the length of the third antennal joint, and by a slightly less distance from each other. Eyes a little diverging beneath, the orbits behind clearly margined. The scutellum is smooth, with a border of widely set apart punctures ; the metanotum is impunctate. The furrow down the centre of the trigonal area is shallow ; the margin of the area is crenulated. Petiole a little longer than wide. Pygidial area elongate, narrow, rounded at the apex ; the base narrower than the apex ; the top closely and finely transversely rugose ; the hair fringe white ; hypopygium not incised. Antennæ blackish above ; the flagellum obscure rufous beneath. Second cubital cellule with the peduncle not much shorter than the width of the cellule itself ; the first recurrent nervure is received in the basal third ; the second a little beyond the apex of the cellule, and almost interstitial. Length 10 mm.

This species comes nearest to *C. instabilis ;* but may easily be known from it by the clypeus not being incised ; by the punctuation being not so strong, especially on the scutellum and median segment ; by the smooth, not rugosely punctured, trigonal area, by the narrower, longer, straighter, pygidial area, which in *instabilis* is wider at the base than at the apex, it bearing also large punctures, and by the shorter second cubital cellule.

CERCERIS INSTABILIS, *Smith*, (Pl. X. f. 4—4 *a*, *b*).

A common and variable species, especially as regards the amount of black on the thorax and abdomen. The ♂ is *C. velox*, Smith.

CERCERIS PULCHRA. (Pl. X. f. 5, *a*, *b*.)

Black, the scape beneath, the cheeks, clypeus, mandibles except at apex, two lines on the pronotum, tegulæ, metanotum, a mark on the base of the second abdominal segment, the third segment except the base in the centre; the fifth segment, the second ventral segment laterally, and the legs, yellow; the petiole and second abdominal segment ferruginous, except the yellow and a black mark on the latter. Clypeus a little gaping at the apex, which is black and incised. Eyes parallel. Hinder ocelli separated from the eyes by near the same distance they are from each other. Body covered with longish pale fulvous pubescence, almost golden on the face; the punctuation is strong and coarse; the scutellum strongly punctured. Trigonal region rugose, and with some stout keels; the central furrow deep. Petiole distinctly longer than broad; pygidial area elongate, gradually narrowed towards the apex, which is almost transverse, but with the edges rounded; the incision in the hypopygium is a little longer than wide, rounded at the base, and becoming wider towards the apex; the top of the pygidial area is irregularly punctured, without a hair fringe, and covered with long pale pubescence. The coxæ are black at the base; the hinder femora are for the greater part black; the hind tibiæ are fuscous on the outer side at the apex. Antennæ rufous; the third joint curved, twice the length of the second and longer than the fourth. The wings are suffused with fuscous; the apex broadly smoky; the second cubital cellule has the peduncle not much shorter than the cellule; the first recurrent nervure is received in the basal fourth; the second a little beyond the second transverse cubital nervure; the nervures fuscous.

The ♂ has the clypeus at the apex broadly rounded; the black on the second abdominal segment is more extended; the fifth segment is black and the sixth yellow; the pygidial area is punctured strongly, narrowed a little at the base, and with the apex transverse. Length 7—8 mm.

This species is represented by numerous examples of both sexes, and it appears to be tolerably constant in coloration. *Vischnu* may be known from it by the black face, by the truncated clypeus, by the absence of yellow on the thorax and on the second abdominal segment; *dentata* by the teeth on the thorax.

CERCERIS VISCHNU. (Pl. X., Fig. 7—7*a*, *b*.)

Black; the scape, the apex of the clypeus, the antennal ridge, a mark on the cheeks, a small mark on the sides of the pronotum, the apex of the third abdominal segment, a mark in the centre of the fifth, the four anterior tibiæ in front, the four anterior tibiæ, the base of the hinder, pale yellow; the femora beneath and the hind coxæ rufous; the petiole and base of second segment ferruginous. Clypeus with the apex projecting, but not sharply and with a slight incision. Ocelli in a curve; the posterior separated from each other by more than the length of the third antennal joint and by its length from each other. The face covered with a silvery pubescence, the rest of the body with pale hair; the punctuation close, rugose. Trigonal area not very clearly defined, rugosely punctured. Petiole a little longer than broad; pygidial area rugose, slightly narrowed towards the apex, which is bluntly rounded; the hair fringe dense, obscure fulvous; the incision in hypopygium a little longer than broad, the base rather sharply pointed. Wings clear hyaline, the apex smoky; the second cubital cellule longer than broad; the recurrent nervure received shortly before the middle. The antennæ have the flagellum pale fulvous beneath; the eyes are parallel.

The ♂ has the clypeus broadly truncate at the apex in the middle, and with the lateral laminæ pale; the clypeus wants the yellow mark; the petiole is black; otherwise as in ♀ except that it is the 6th abdominal segment which is marked with yellow. Length ♀ nearly 9 mm; ♂ 7 mm.

A distinct species.

What appears to be this species has a small yellow mark at the base of the abdomen, the petiole beneath and laterally and the base of the second segment are rufous and there is a small white mark on the base of the latter.

CERCERIS TRISTIS, *sp. nov.* (Pl. X. f. 7, *a*, *b*).

Eyes parallel. Ocelli not forming a triangle; the posterior separated from the eyes by nearly the length of the second and third joints united and from each other by less than the length of the third. Middle lobe of the clypeus convex, gaping at the apex, which is broadly and narrowly incised. Punctuation of head close and rather strong; the face densely covered with silvery hair. Head below the antennæ and the orbits for the length of the scape above the base of the antennæ, and the mandibles, except at the apex, yellow. Extreme apex of clypeus black. Thorax strongly punctured, more coarsely on the pleuræ; the tegulæ, a line on either side of the pronotum, and metanotum, yellow. Trigonal area obscurely aciculated, the sides punctured irregularly; the central furrow crenulated. Petiole longer than broad, distinctly bulging out at the sides; the segments with a moderately strong punctuation; a mark broader than long on the base of the second segment; the apex of the third segment (narrowed in the centre) and a narrower belt on the fifth, also narrowed in the centre, yellow. Pygidial area elongated, narrower at base than at apex, the latter bluntly rounded; the surface irregularly rugose. Incision in hypopygium broad, a little longer than broad, gaping at the apex, the base broadly rounded. Lateral hair fringe sparse, silvery. Legs black; the apex of coxæ and trochanters; the greater part of the femora beneath; and the tibiæ and tarsi, except the apices of the posterior, yellow.

The ♂ has the clypeus slightly convex; the apex projecting in the middle, black and with a short broad, blunt tooth in the middle. The coloration is as in the ♀ except that the fifth segment is entirely black and the sixth nearly entirely yellow. Pygidial area of equal width throughout; depressed before the apex, shining and sparsely punctured. Length 7—9 mm.

May be known from *C. novaræ* by the median segment wanting yellow marks; by there being only a central basal yellow mark on the second abdominal segment; by the legs being broadly black at the base, by the third joint of the flagellum being distinctly longer than the fourth; by the central lobe of clypeus being roundly convex and gaping at the apex, &c.

CERCERIS FERVENS, *Smith.*

It is probable that this will prove to be identical with *C. novaræ*. So far as the description of the ♀ goes the only difference is that in *fervens* there are two lines on the scutellum; but in both the females of *Novaræ* I have examined, there is a minute yellow mark on either side of it. Smith's description of the ♂ differs moreover, it having the sixth segment (not the fifth) yellow marked; and apparently the median segment wants the yellow marks.

Smith, I may add, named, in Mr. Rothney's collection, the ♂ of the species I have called *Vischnu*, *fervens*; but it does not agree with the description of *fervens*; and my specimen is certainly not the ♂ of *Novaræ*. It is possible that Smith has assigned the wrong ♂ to his *fervens*.

CERCERIS NOVARÆ, *Sauss.*, (Pl. X. f. 8, *a*, *b*).

Clypeus flat, slightly convex in the middle; the apex projecting a little beyond the lateral pieces; the apex truncated, but with the sides rounded. Eyes a little converging beneath. Ocelli not forming a triangle, the anterior being too much in front of the posterior; the posterior separated from the eyes by a little more than the length of the third antennal joint, and by its length from each other. Front and vertex strongly punctured; the face and clypeus with shallow punctures. The face, oral region, antennal keel and the orbits to the length of the scape above the base of the antennæ; the mandibles, except at the apex, and a spot behind the eye near the top, yellow. The vertex is sparsely pilose. Thorax more strongly punctured than the head; the punctures larger and wider apart, the pleuræ more coarsely punctured than the mesonotum. Trigonal area impunctate, furrowed down the centre, the furrow crenulated. Two marks on the pronotum, a spot on the mesopleura, tegulæ, a small mark on the sides of the scutellum, the metanotum and two large oblong marks on the median segment, yellow. Mesopleural furrow, wide, deep. Apex of median segment gradually rounded above, the apical part rather abrupt, and with two deep, shining, somewhat triangular depressions at the extreme apex. Petiole longer than broad, slightly bulging out at the middle, coarsely punctured. The other segments are also strongly punctured. Pygidial area an elongated oval, narrowed at base and apex, the surface irregularly rugose. Hypopygial incision not reaching to the middle of the segment, longer than broad, rather acutely pointed at the apex. The lateral hair fringe dense, golden-fulvous. There is a broad band on the base of the second segment, the whole of the third segment, except a somewhat semicircular black mark in the middle at the base and a similar amount of black on the fifth, yellow. The legs are yellow, except the apical half of the posterior femora and tibiæ. The scape is yellow; the flagellum fulvous beneath; the third and fourth joints are sub-equal.

The ♂ is similarly coloured, except that the mesopleuræ want the yellow mark and the scutellum is entirely yellow. Length 7—10 mm.

CERCERIS WROUGHTONI, *sp. nov.* (Pl. X. f. 9, *a*, *b*).

Black, shining, thorax, and head punctured, the abdomen impunctate, smooth; the clypeus, the cheeks to above the base of the antennæ, the antennal ridge, the scape beneath, a large broad line behind the eyes, a line on the pronotum, scutellum, metanotum, two small marks on the middle of the median segment, the petiole, except a broad stripe down the centre, the base of the second and third segments all round, the edge of the fourth, and a large mark in its centre, a similar mark on the fifth; and the basal three ventral segments, for the greater part, clear yellow; the flagellum beneath and a large mark on either side of the median segment rufo-fulvous; legs fulvous, the anterior four in front and the hinder femora in part, pale yellow. Wings fuscous, the apex much darker, the stigma fulvous. Antennæ with the third joint about one quarter longer than the fourth. Clypeus flat, the apex black, roundly and broadly incised; its sides and the cheeks bearing a silvery pubescence. Ocelli forming almost a triangle, the posterior separated from the eyes by more than the length of the third antennal joint; and by about its length from each other. The pubescence on the head is longish and pale; the punctuation moderately strong, and all the punctures deeply separated. Thorax moderately strongly punctured, covered with a pale pubescence; the pronotum above saddle-shaped; the transverse furrow in the mesopleura wide, deep and complete; scutellum sparsely punctured; trigonal area smooth, impunctate, furrowed down the middle; metapleuræ aciculate, the base with a few stout striæ. Petiole wider than long, bulging out in the centre; sparsely and finely punctured; the fifth segment also sparsely punctured; the others obscurely aciculate. Pygidial area large, rounded at apex, not narrowed at the base; transversly striolated; incision in hypopygium not reaching to the middle, a little longer than wide, rounded at the base. Hinder tibiæ very stoutly and closely spined. Second cubital cellule longer than broad, rounded above, above shortly pedunculated; the recurrent nervure received shortly before the middle.

The ♂ has the face from the top of the antennal ridge entirely yellow; the clypeus flattish; the apex rounded, almost transverse; the lateral plates incised; there is a small yellow mark below the tubercles; there are two large yellow marks on the median segments; the fourth segment is almost entirely yellow; the fifth has a narrow yellow border on the apex, the sixth is almost entirely yellow; the sides of the apical segment are yellow: the legs are clear yellow; the hinder femora are marked with black, the hind tibiæ are broadly black at the apex and the hind tarsi are fuscous; otherwise coloured as in ♀. Pygidial area with large punctures, the apex almost transverse. Length 11 mm.

Easily recognised by the smooth impunctate abdomen.

CERCERIS PICTIVENTRIS, *Dbm.*

This species is no doubt identical with *C. novaræ,* at least that species agrees with the rather laconic description given by Dahlbom—Abdomen nigrum, flavo-fulvo—aut albo-fasciatum . . . petiolus nigrum . . . segmenta ventralia plurima flavo-fasciata aut maculata—Corpus subparvum . . . abdomen fasciis citrinis pleurumque 3 raro pluribus; ♀ segmento ventrali valvutæ proximo ad marginem apicalem intergerrimo.

Schletterer (*Zool. Jahrb.* II., p. 499) quotes doubtfully *C. pictiventris* of Gerstacker (*Monatsb. Berl. Akad. Wiss.*, 509) as a synonym. Gerstacker's species was from West Africa Dahlbom's from Java.

CERCERIS DENTATA, *sp. nov.* (Pl. X., f. 10, *a*, *b*.)

Black; the clypeus, cheeks, antennal ridge, mandibles except at the apex, a spot behind the eyes, an interrupted line on the pronotum, two marks on the scutellum, two marks on the mesopleuræ, metanotum, two elongated marks on the median segment, two small marks on the petiole, a line on the apex of the second and third abdominal segments, the fifth, except at the base, the femora beneath and the tibiæ and tarsi, clear yellow; the petiole, coxæ, and femora, ferruginous; wings hyaline; very slightly infuscated at the apex. Clypeus depressed, the apex transverse. Eyes a little diverging; ocelli not forming a triangle, the posterior separated from the eyes by the length of the third antennal joint and from each other by the length of the fourth. Body covered with a white pubescence, silvery on the face; the punctuation moderately strong. The mesosternum in the middle projects into two stout teeth; the posterior being the larger. Trigonal area elongated, reaching nearly to the apex of the segment, much longer than broad, smooth, impunctate, a fovea on either side of the furrow. Scutellum almost impunctate. Mesopleuræ rugosely punctured, convex, bulging out above; metapleuræ finely and closely rugose at the base, the apex with large punctures. Petiole hardly longer than broad. Pygidial area narrowed at base and apex, bulging out gradually in the middle, the apex above black, the rest dull rufous, and punctured; the hair fringe dense, obscure white. Ventral surface with second and third segments banded with pale yellow; covered with long white hair; the incision in apical segment reaching near to the middle, rounded at base. Wings shorter than usual; the second cubital cellule twice longer than wide; the recurrent nervure received in the basal third. Length 8—9 mm.

The spines on the mesosternum separate readily this distinct species.

CERCERIS SULPHUREA, *sp. nov.* (Pl. X., f. 11, *a*, *b*).

Sulphureous; the ocellar region and three lines on the mesonotum, sordid rufous; wings clear hyaline, the apex from a little before the end of the radial cellule fuscous, the nervures fuscous; the flagellum of the antennæ pale rufous. Clypeus convex, broadly rounded at the apex. Eyes slightly diverging; posterior ocelli separated from each other by the length of the third and from the eyes by the length of the first antennal joint. The third antennal joint only a little longer than the fourth. Body covered with long white hair; that on the face silvery. Punctuation moderately strong. Trigonal area punctured. Petiole nodose, longer than broad. Pygidial area broad, but longer than broad, punctured, the apex bluntly rounded. Second cubital cellule not much longer than broad; the first recurrent nervure almost interstitial. ♂. Length 8 mm.

CERCERIS TETRADONTA, *sp. nov.* (Pl. X. f. 12, *a*, *b*).

Black, closely and rather strongly punctured, the clypeus, the cheeks broadly from near to the top of the antennal ridge, the antennal ridge; scape beneath, the base of the mandibles; two small spots behind the ocelli, a large line behind the eyes, a broad line on the side of the pronotum, a mark on the side of the scutellum, metanotum, two large marks on the sides of the median segment, tegulæ, tubercles, a small spot below them, the sides of the petiole, and a short line on the edges of the other segments and on the edges of the third to fifth ventral segments, whitish-yellow. Ocelli not forming a triangle; the outer separated from the eyes by a little more than the length of the third antennal joint and by fully its length from each other; eyes a little converging towards the clypeus. Flagellum rufous beneath, fuscous above; the third and fourth joints sub-equal. Clypeus flat, the apex a little projecting and armed with four stout, blunt teeth. Pronotum rounded at the sides and with an oblique slope in front. Mesopleural furrow indistinct. Trigonal area smooth, impunctate, shining; the central furrow narrow, metapleuræ at base strongly striolated; black above; the rest reddish, the extreme apex of the median segment being also reddish. Petiole rufous, broader than long; the base oblique. Pygidial area reticulated; narrowed almost to a point at the base; the apex transverse. Incision in hypopygium not reaching to the middle, longer than broad, rounded at the base. The basal ventral segment is entirely rufous; the others are broadly rufous in the middle. Wings almost hyaline, the apex infuscated; the second cubital cellule arched, receiving the petiole almost in the middle; the recurrent nervure received a little before the middle of the cellule. Legs rufous in front, more or less whitish-yellow beneath; the hind tibiæ fuscous behind, the hind tarsi for the greater part fuscous. Length 6—7 mm.

The ♂ is smaller and similarly colored, but with the yellow marks more reduced; the clypeus slightly convex; the apex transverse, except that a short, not very distinct tooth projects in the middle. The femora are broadly lined with black laterally and above, especially the anterior four.

A well-marked species.

CERCERIS PENTADONTA. (Pl. X., f. 13, *a*, *b*.)

Eyes almost parallel. Ocelli in a triangle, the hinder separated from the eyes by nearly the length of the second and third antennal joints united, and from each other by less than the length of the third. Lobe of clypeus obliquely projecting, thick, much broader than long, slightly incised at the apex; the apex with five teeth; the central and outer sharply pointed, the other two broader and truncated at the apex. Third antennal joint not much longer than the fourth and not twice the length of the second. The punctuation on the head is close, moderately strong; the pubescence short and sparse. Thorax opaque, aciculate, and bearing widely separated shallow punctures, those on the median segment more widely separated than those on the mesonotum. Triangular area of median segment opaque, finely and closely rugose, channelled down the middle. The oblique furrow on the mesopleura is wide, deep and obliquely striolated; the metapleuræ finely obliquely striolated; median segment short, its apex obliquely and rather abruptly rounded. Petiole longer than broad, dilated slightly in the middle, clearly separated from the second segment, and covered with moderately large punctures. The other segments are similarly punctured, the punctuation becoming sparser towards the apex. Pygidial area opaque, irregularly and slightly reticulated, much narrowed at the base, the apex rounded. Incision on hypopygium extending beyond the middle, rounded at base, of nearly equal width throughout. The flagellum is rufo-fulvous beneath, the inner orbits of the eyes, the antennal tubercle, the pronotum, metanotum, the third abdominal segment, except at apex, and a band occupying the apical half of the fifth segment, rufo-yellow.* Legs inclining to piceous; the anterior knees, tibiæ and tarsi, yellow in front; the spurs white; the spines blackish. The second recurrent nervure is almost interstitial; second cubital cellule rather shortly pedunculated; the apical nervure longer than the basal. The wings, although, dark smoky throughout, are darker along the radial cellules. Length 8 mm.

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* I suspect that the rufous tint is caused by cyanide of potassium.

CERCERIS INTERSTINCTA, *Fab.*

What this species may be is rather doubtful. On the whole the description fits best with the ♂ of *humbertiana*, but it differs from it in no mention being made of the two marks on the median segment. With this exception, however, the description, so far as it goes, suits *humbertiana* fairly well.

CERCERIS DISSECTA, *Fab.*

I am quite unable to recognise this species from the description. It may be added that neither Smith nor Schletterer includes this species in their Catalogues.

The description of the Fabrician species are subjoined.

PHILANTHUS INTERSTINCTUS.

P. niger flavo varius abdominis segmento primo rufo. Alis apice nigris.

Habitat in India Dom. Daldorff.

Statura et magnitudo P. ruficornis, antennæ ferrugineæ articulo primo flavo. Caput flavum vertice nigro. Thorax niger, margine antico, puncto calloso ante, lineis duabus scutelli, macula utrinque sub alis, et subscutello flavis. Abdomen nigrum segmento primo rufo, reliquis apice flavis, ano tamen toto nigro, alæ albæ, anticæ apice nigræ. Pedes flavi geniculis nigris.

PHILANTHUS DISSECTUS.

P. niger flavo varius, abdominis basi rufo, macula flava.

Habitat in India Dom. Daldorff.

Praecedente paullo minor, antennæ rufæ, basi flavæ; caput nigrum, labio albo, thorax niger margine antico utrinque lineola, puncto ante alas scutelloque flavis; abdomen nigrum petiolo toto ferrugineo, segmento primo basi ferrugineo, macula flava, secundo quartoque apice imprimis ad latera flavis. Pedes flavi femoribus supra nigris.

B. Clypeus porret in ♀.

CERCIRIS ORIENTALIS, *Smith*, (Pl. X., f. 14, *a*, *b*).

The largest of the oriental species. In the only example I have seen the ocelli are in a black patch; and the sternum is also black. The posterior ocelli are separated from the eyes by fully the length of the second and third joints united; and from each other by the length of the fourth. Trigonal area broad, coarsely aciculate. Petiole broader than long. Pygidial area narrowed a little at base and apex; the apex rounded; the hair-fringe dense pale fulvous; incision in hypopygium reaching near to the middle; there is a tuft of hairs on the apex of the segment at the sides. The second cubital cellule forms almost a semi-circle; and receives the recurrent nervure near the middle.

CERCERIS NEBULOSA, *sp. nov.* (Pl. X., f. 15, *a*, *b*.)

Eyes slightly diverging beneath. Ocelli hardly forming a triangle; the posterior separated from the eyes by fully the length of the third antennal joint, and by the length of the fourth from each other. Clypeus flat, the middle at the apex turned outwardly, widely semi-circularly incised and separated from the lateral pieces by projecting beyond them. Head closely rugosely punctured; the cheeks and lateral margin of clypeus densely covered with silvery white hair. Mesonotum closely and finely longitudinally rugosely punctured; the pleuræ coarsely rugose; trigonal area finely rugose. Abdomen twice the length of the thorax, and narrower than it; the petiole not much broader than long; the punctuation of the segments not very strong; the pygidial area closely rugose, hardly narrowed at the base; the apex transverse: the incision on hypopygium longer than broad; rounded at the base, dilated at the apex. The third joint of antennæ longer and thinner than the fourth. The cheeks, clypeus, orbits broadly above the base of the antennæ; a spot behind the eyes near the top, a band on the pronotum, scutellum, post scutellum, a narrow band on the base of the second abdominal segment, the extreme apex of the petiole, the apical half of the third segment and the extreme apex of the fourth, reddish-fulvous. Legs black; the anterior tibiæ and tarsi obscure testaceous in front. Length 15 mm.

CERCERIS HUMBERTIANA (Pl. X., f. 16, *a*, *b*.)

In the ♂ the eyes are parallel. The hinder ocelli are separated from them by a little more than the length of the third antennal joint, and by nearly the same distance from each other. The middle of the clypeus projects considerably, the projection almost truncated at the apex, except that there is a waved projection in the middle; the sides of the projection are obliquely curved. The lateral hair fringe is dense and golden. The third antennal joint is a little longer than the fourth and attenuated at the apex. The puncturing on the top of the head is very deep and coarse, on the thorax it is not quite so strong. The trigonal area of median segment is smooth, shining, and impunctuate, and has very narrow and indistinct furrow down the middle. Pygidial area bearing large oval punctures; it is a little narrowed and truncated at the apex and has there a golden pile. The petiole is broader than long and rugosely punctured. The other segments bear large, separated punctures of moderate length.

May be known from the ♂ of *instabilis* by the clypeus of the latter not projecting so squarely in the middle; by the trigonal area being coarsely longitudinally striolated; by the petiole being much narrower, being clearly longer than broad; by the yellow band on the vertex, &c.

Apparently a common species.

CERCERIS EMORTUALIS.

I should say, judging how very variable *humbertiana* is, that this will prove to be a variety of the latter.

CERCERIS HILARIS, *Smith* (Pl. X., f. 17, *a*, *b*.)

The clypeus is longer than broad, and becomes gradually broader towards the apex; the five basal joints of the flagellum of the antennæ are rufous, and the remaining joints are rufous beneath; the third joint is slightly curved, and about one-third longer than the fourth; the trigonal area is coarsely longitudinally striolate; the hypopygium is transversely rugose, and narrowed gradually towards the apex, and rounded there. Comes nearest to *C. flavopicta*, but is larger, has the clypeus emarginate, the trigonal area striolate, &c.

PSENIDÆ.

1. PSEN RUFIVENTRIS, *sp. nov.*

Niger, mandibulis, pedibus abdomineque rufis; alis clare hyalinis, nervis nigris. ♀. Long. 9 mm.

Antennæ closely covered with a pale microscopic pile; becoming gradually thickened towards the apex; the scape curved, bare; as long as the third joint, which is about a quarter longer than the fourth. Head shining, impunctate above; the front and clypeus closely and finely punctured. Clypeus broadly convex, the apex depressed, gaping and transverse in the middle. Ocelli in pits; a short transverse furrow behind them; the hinder separated from the eyes by about the length of the fourth antennal joint and by a somewhat greater distance from each other. Eyes parallel, coarsely facetted. Mandibles shining, somewhat punctured at the base. The face, cheeks, base of front and of clypeus densely covered with golden hair; the outer orbits of the eyes more sparsely with silvery. Thorax opaque on the mesonotum, the rest shining, impunctate. The apex of median segment irregularly reticulated, laterally striolated. Basal area of median segment semi-circular; depressed at the apex, and bearing some stout keels and with a straight, finely aciculated, shallow furrow in the centre. Pronotum with a slight depression in the middle. The sternum, median segment and pleuræ sparsely covered with long silvery hair. Petiole curved, longer than the thorax. Abdomen shining, impunctate, glabrous. Pygidial area shining, convex, keeled laterally. Legs covered somewhat thickly with white, glistening hair. The second cubital cellule above (the nervures straight) is a little shorter than the space bounded by the first recurrent and second transverse cubital nervures and less than half the length of the third cellule; the recurrent nervures are received about the same distance behind the transverse cubitals. The antennæ are pale fulvous; the mandibles at the base pale testaceous, black at the apex; the legs (except the coxæ) pale ferruginous; the posterior femora and tibiæ a little infuscated; abdomen piceo-ferrugineous, infuscated in the middle.

Psen erraticus, Smith (*Proc. Linn. Soc.* IV., p. 85), from Celebes agrees closely in coloration with the species here described; but no details beyond color are given, and in that respect it differs from *rufiventris* in having the nervures and stigma pale ferruginous, not deep black as in our species.

Hab. Madras (*Rothney*).

PSEN CLAVATUS, *sp. nov.*

Smaller than *P. rufiventris* (8 mm. only) differing from it in the eyes being rounded in front, diverging at apex, in the antennæ being distinctly clavate; with the third joint not twice the length of the second (in *rufiventris* it is three times) and not much longer than the fourth; in the third joint being nearly twice the length of the penultimate; in there being no furrow behind the ocelli; in the base of the median segment being not depressed, and with three keels down the central part,—one central and two lateral keels; the abdomen apart from the black petiole, is entirely rufous; the second cubital cellule is narrowed almost to a point at the top: the head and thorax are more distinctly aciculate, and there are two shallow furrows on the mesonotum, only the four anterior knees, tibiæ and tarsi are testaceous, this being also the case with the hinder. ♀.

Hab. Poona (*Wroughton*).

3. PSEN ORIENTALIS, *sp. nov.*

Niger, nitidus, alis fere hyalinis, nervis nigris, ♀. Long. 11 mm.

Antennæ distinctly thickened towards the apex, the flagellum closely covered with a whitish pubescence, the scape thickened, shorter than the third joint, which is twice the length of the fourth. Front and vertex shining, impunctate, sparsely pubescent; the head below the antennæ covered densely with white depressed hair. Ocellar regions raised, the ocelli not in pits. Eyes converging perceptibly towards the bottom. Clypeus almost as in *P. rufiventris.* Thorax shining, impunctate; the basal area of median segment not so clearly defined as in *P. rufiventris*; the keels less distinct; and the apex of the segment is much less distinctly reticulated, and there is a large depression in the centre. Petiole on lower side bearing long white hair. Pygidial area flat above, not convex, the sides keeled, the base impunctate, the rest finely and closely punctured; the sides covered with longish fulvous hair. Legs covered with white hair; the hind spurs and claws ferruginous. The second cubital cellule at the top is shorter than the space bounded by the first recurrent and second transverse cubital nervures; the first recurrent nervure is received in the basal third of the cellule, the second is almost interstitial.

Apart from the difference in coloration, *P. orientalis* may be known from *P. rufiventris* by the third antennal joint being twice the length of the fourth, by the less clearly hyaline wings, by the interstitial second recurrent nervure, &c.

Hab. Madras (*Rothney*).

CRABRONIDÆ.

CRABRO.

I. *Abdomen petiolated.*

1. CRABRO FLAVOPICTA, Smith, *Cat. Hym. Ins.* IV., 391 4.
Hab. Northern India.[1]

2. CRABRO BUDDHA Cam.
Hab. Tirhoot, Bombay, Madras.

3. CRABRO ODONTOPHORA, Cam. *postea.*
Hab. Barrackpore.

II. *Abdomen sessile.*

4. CRABRO ARDENS, Cam., *postea.*
Hab. Barrackpore (*Rothney*).

5. CRABRO ARGENTATUS, Saint-Fargeau, *Ann. Soc. Ent. Fr.* III., 710, 11; *Nat. Hist. Hym. Ins.* III. 194, 1;[1] Dahlbom, *Hym. Eur.* I., 385, 255.
Hab. India.[1]

6. CRABRO FAMILIARIS, Smith, *Proc. Linn. Soc.* II., 106, 1.[1]
Hab. Borneo[1] (*Wallace*).

7. CRABRO FUSCIPENNIS, St.-Fargeau, *Ann. Soc. Ent. Fr.* III., 710, 11; *Nat. Hist. Hym. Ins.* III., 113;[1] Dahlbom, *Hym. Eur.* I., 385, 255.
Hab. India.[1]

8. CRABRO INSIGNIS, Smith, *Cat. Hym. Ins.* IV., 422, 145.[1]
Hab. India.[1]

9. CRABRO NANUS, Cam. *postea.*
Hab. Barrackpore.

10. CRABRO RUGOSUS, Smith, *Proc. Linn. Soc.* II., 106, 2.[1]
Hab. Borneo[1] (*Wallace*).

Hab. Northern India.[1]

CRABRO ODONTOPHORA, *sp. nov.* (Pl. X. f. 20, *a*, *b*).

Antennæ covered with a microscopic white pile, black, the scape lined with yellow beneath ; the third joint nearly twice the length of the fourth. Head with a plumbeous hue, shining, the front, cheeks and clypeus densely covered with silvery pubescence, the outer orbits of the eyes on the lower side with silvery and the vertex with a pale fuscous hair. Ocelli in a triangle, the hinder separated from the eyes by nearly the length of the third and from each other by nearly the length of the fourth antennal joint. A shallow furrow runs down the front from the vertex; the front is only slightly excavated ; the clypeus is bluntly keeled, the apex projecting in the middle, almost truncated, but with the sides rounded. Mandibles yellow, black at the apex, covered sparsely with white, glistening hair. Thorax with a plumbeous hue, shining, very minutely punctured on the mesonotum and scutellum ; the pronotum narrowed in the middle in front and with a minute furrow on the top ; the pleural furrows crenulated ; median segment elongate ; shining, covered with long white hair ; furrowed down the middle, the centre at base finely aciculate, the sides finely rugose ; metapleuræ shining, not hollowed, almost impunctate. Abdomen shining, impunctate ; the petiole hollowed at the base above ; a small mark on either side at its apex ; a large mark on the sides of the third and fourth ; the apex broadly rounded, almost truncated, but with the sides rounded ; pygidium punctured, hollowed in the centre. Legs : hind femora and tibiæ clavate ; the latter with a broad furrow on the apical half on the outer side, the former with a broad furrow in the middle on the lower side ; basal joint of anterior tarsi twisted, dilated at the base, the dilatation forming a blunt tooth ; hind calcaria reaching to the middle of metatarsus ; hind coxæ at the base projecting in a stout curved tooth; metatarsus curved at the base beneath and densely pilose, longer than all the other joints united. Hypopygium curved, dilated at the base and armed there with two stout, curved, sharp teeth. The recurrent nervure received considerably before the middle of the radial cellule. Length 7—8 mm.

CRABRO ORIENTALIS, *sp. nov.*

Scape and second joint of the antennæ clear straw yellow; the other joints black, fuscous beneath, covered with a white microscopic pile; the third joint a very little longer than the fourth. Vertex opaque, finely and closely rugose; covered with a short fuscous-black pubescence; ocelli in a curve, the hinder separated by about the length of the second and third antennal joints united from the eyes, and by a slightly less distance from each other. Front deeply excavated, margined at the top, closely covered with a silvery pile; clypeus slightly convex and with a fine keel down the middle; densely covered with golden pubescence. Mandibles shining, clear yellow, black at the apex. Thorax opaque, alutaceous. The furrow at the base of scutellum crenulated; scutellum longitudinally striolated (at least on the black part), rounded behind; metanotum coarsely longitudinally striolated. Median segment rugosely punctured, irregularly obliquely striolated; the centre furrowed (the furrow at base narrow). Mesopleuræ opaque, alutaceous, the furrows crenulated; metapleuræ finely transversely striated. Petiole fully three-fourths of the total length of the abdomen, the apex nodose, opaque, the base shining, finely punctured. Abdomen opaque, the apical segment punctured. There is a squarish mark on either side of the apex of the petiole; a broad elongated mark on the side of the second segment; a small mark on the side of the third, a broad band on either side of the fourth, narrowed on the inner side and the whole of the fifth segment, yellow. Legs covered with a whitish pubescence; clear yellow; the coxæ and femora to near the apex, and a line on the tibiæ, black; the outer spur of hind tibiæ nearly as long as the metatarsus, broadly dilated. The recurrent nervure is received in the middle of the radial cellule.

May be known from *C. buddha* by there being no shining fovea along the inner orbits of the eyes; by the scutellum being longitudinally striolated; by the petiole and second abdominal segment being marked with yellow, and by the fuscous wings. Length 8 mm.

CRABRO ARDENS, *sp. nov.*

Head shining, finely punctured, less strongly on the vertex than on the front; there is a minute furrow between the ocelli and a shorter one on the outer side; the ocelli hardly form a triangle, the hinder being too close together. Frontal furrow moderately deep and wide. Cheeks and clypeus densely covered with silvery hair; the outer orbits on the lower side not so thickly haired; clypeus keeled in the centre; the sides and apex yellow; mandibles yellow, black at extreme apex. Thorax shining, more strongly punctured than the front, shining; shortly pilose; the sternum densely covered with short pale pubescence; mesopleural furrow wide, crenulated; there is a small round fovea on the posterior lower edge of the mesopleuræ. Pronotum above distinctly raised, transverse, the sides of the raised part oblique; the hinder part of the prothorax separated by a wide and deep depression from the anterior. Scutellum finely punctured, the sides narrowed behind, margined; the basal depression crenulated. Median segment covered with depressed pale hairs; the basal area bounded by a curved furrow, and with some longitudinal striæ; the apical fovea longish, wide; metapleuræ striated.

Abdomen shining, very finely punctured; the sides and apex covered with whitish pubescence; petiole shining, impunctate, depressed at the base; twice longer than wide; pygidial area almost truncate, rounded laterally. Legs at base and tibiæ and tarsi closely covered with a pale pubescence, the anterior broadly bright yellow beneath; the tarsi fuscous-black. Posterior spurs thick, dilated, pale, fully three-fourths of the length of the metatarsus. Antennæ rather densely and longly pilose; the third joint not much longer than the fourth; the scape punctured, yellow in the centre beneath; the base of flagellum fuscous on the lower side. The recurrent nervure is received considerably before the middle of the radial cellule. The tubercles in front and the greater part of the propleuræ are bright yellow.

The ♀ has the oral region and mandibles not yellow; the latter are at the apex brownish; the palpi yellowish; there is a narrow line on the pronotum; the propleuræ are for the greater part black; the front legs are hardly yellow in front; the pygidial area very shining, depressed in the middle, foveate at the apex and indistinctly punctured at the base; the scape is yellow beneath, and the third joint is longer in proportion to the fourth than in the ♂, besides being thinner at the base. Length 5 mm.

CRABRO NANUS, *sp. nov.*

Head minutely punctured on the front; ocelli in a curve, in pits; a minute furrow in their middle behind; frontal depression wide, deep, shining, a broad keel in the centre; clypeus not carinate, but with the centre broadly projecting at the apex; densely covered with silvery pubescence, as are also the cheeks; outer orbits of the eyes distinctly margined, and bearing a silvery pubescence; the front and vertex bearing a longish blackish pubescence; mandibles yellowish, black at the apex. Scape of antennæ yellow beneath, the flagellum obscure brownish beneath, stout, pilose; the third joint narrow at base, dilated at the apex, not much longer than the fourth. Thorax shining, above very obscurely punctured; the pleuræ, if anything, more distinctly. Pronotum in the middle retreating, the sides broadly rounded, the top not raised, and having a gradually rounded slope to the base; mesopleural suture wide, crenulated, the fovea distinct. There is an indistinct furrow in the centre of the mesonotum, and two foveæ towards the base. Median segment short, the base dilated, the rest with a sharp oblique slope; the basal area irregularly reticulated; the centre is very slightly hollowed, but with the sides of the hollow margined by keels, which unite at the apex; the outer edges are also keeled, the keels converging beneath; metapleural shagreened, and bearing some irregular striae. Abdomen shining, covered almost all over with a pale pubescence; the basal segment, becoming gradually dilated to the apex, which is slightly shorter than the total length; the apical segments rather strongly punctured; the pygidial area rounded at the apex; the ventral segments punctured at the apex. Legs pilose; the long spur of the hind tibiæ reaches to the middle of the metatarsus. The recurrent nervure is received near the middle of the radial cellule. Length 3½ mm.

DASYPROCTUS, *Lep.*

1. DASYPROCTUS CEYLONICUS.
   Dasyproctus ceylonicus, Saussure, *Hym. d. Novara Reise*, 85, f. 51.
   Hab. Ceylon.

OXYBELUS.

1. OXYBELUS AGILIS, Smith, *Cat. Hym. Ins.* IV., 387, 25.[1]
   Hab. India.[1]

2. OXYBELUS ARGENTEOLINEATUS, Cam. *postea.*
   Hab. Barrackpore (*Rothney*).

3. OXYBELUS BELLUS, Cam. *postea.*
Hab. Poona (*Wroughton*).

4. OXYBELUS CANESCENS, Cam. *postea.*
Hab. Barrackpore (*Rothney*).

5. OXYBELUS FLAVIPES, Cam. *postea.*
Hab. Barrackpore (*Rothney*).

6. OXYBELUS FULVOPILOSUS, Cam. *postea.*
Hab. Barrackpore (*Rothney*).

7. OXYBELUS INSULARIS, Kohl, *Terméz. Füzetek.* VIII., 109.[1]
Hab. Ceylon.[1]

8. OXYBELUS NITIDUS, *Cam. postea.*
Hab. Barrackpore (*Rothney*).

9. OXYBELUS ROBUSTUS, *Cam. postea.*
Hab. Poona (*Wroughton*).

10. OXYBELUS RUFICORNIS, Smith, *Cat. Hym. Ins.* IV., 388, 27.[1]
Hab. India.[1]

11. OXYBELUS SABULOSUS, Smith, *Cat. Hym. Ins.* IV., 288, 28.[1]
Hab. India.[1]

12. OXYBELUS SQUAMOSUS, Smith, *Trans. Ent. Soc.*, 1875, 38.
Hab. Barrackpore (*Rothney*).

13. OXYBELUS TRIDENTATUS, Smith, *Cat. Hym. Ins.* IV., 387, 26.[1]
Hab. India.[1]

A. *Thorax with laminæ.*

OXYBELUS ROBUSTUS, *sp. nov.* (Pl. X. f. 21—21*a.*)

Black, a line on the pronotum, two marks on the scutellum, the lateral plates, and a band on each side of the abdominal segments 1—4, white; legs red, the coxæ, trochanters, four posterior tarsi and the four posterior tibiæ behind, black; wings clear hyaline. Eyes wide apart, straight, a little diverging beneath. Antennæ dull rufous, the scape more or less fuscous; the third joint a very little longer than the fourth. Head closely punctured, from a little below the ocelli closely covered with pale silvery hair. Ocelli in a curve, the posterior separated from the eyes by the length of the second, and from each other by the length of the second and third antennal joints united. Apex of clypeus transverse; mandibles obscure rufous. Thorax shining, punctured, the pleuræ more closely than the mesonotum, sparsely covered with a short silvery pubescence; the oblique furrow on the mesopleuræ broad and shallow. Scutellum convex, sparsely covered with large round punctures, the centre keeled, but not strongly, the apex incised in the middle. The lateral plates large, curved laterally and ending in a stout, triangular tooth; the central lamina broader than long, the sides rounded, narrowed at base and apex, the apex with a broad, shallow incision. Abdomen more finely and closely punctured than the thorax; the ventral surface with the punctuation much sparser; the segments at the apex narrowly edged with dirty white. Tibiæ and tarsi bearing a silvery white pubescence; the tibial and tarsal spines white. The recurrent nervure is received almost in the centre of the radial cellule. Length nearly 9 mm.

Most nearly related to *O. squamosus*; but that species may be known from it by the eyes being rounded, not straight, and meeting much closer together, by the blackish antennæ, by the central lamina being rufous and longer than broad (see Pl. X., f. 24).

OXYBELUS FLAVIPES, *sp nov.*

Head closely punctured, the face, cheeks and front densely covered with golden pubescence; the clypeus in the middle, the mandibles and trophi yellow, the tips of the mandibles black, piceous-red before the black. Thorax punctured, closely covered with pale pubescence ; a line on the collar, tubercles, tegulæ, the scutellum, except at the apex, clear stramineous-yellow ; the lateral plates of the metanotum pale yellow. Pronotum rounded, the sides obliquely truncated ; scutellum stoutly keeled down the centre ; the central mucor longer than broad, very slightly and gradually dilated towards the apex, which is acutely and somewhat triangularly, incised ; the lateral plates are large, curved outwardly and ending in a sharply triangular point ; median segment with an oblique slope, finely shagreened ; there is a short furrow below the central mucor ; two keels run from the lateral plates, becoming united near the apex of the segment ; and two other keels run from the sides ; metapleuræ finely longitudinally shagreened. Abdomen shining, closely punctured ; a yellow line on the side of the segments ; pygidial area densely covered with stiff depressed golden-fulvous hairs. Wings clear hyaline, the recurrent nervure quite straight, not oblique, and received before the middle of the radial cellule. Length nearly 5 mm.

Oxybelus canescens *sp nov.* (Pl. X., f. 22.)

Head closely punctured, densely covered with long grey pubescence. Ocelli separated from each other by twice the distance they are from the eyes, which are very slightly diverging towards the clypeus. Mandibles pale yellow, the apex black. Collar projecting in the middle, slightly concave, and with an oblique slope to the head. Thorax densely covered with a greyish pubescence, strongly punctured, the pleuræ almost rugose ; the oblique furrow crenulated ; there is also a longitudinal furrow, and a narrow oblique one runs down from the apex of the fore wings. Lateral laminæ curved, bi-dentate at the apex, the central curved, convex above, slightly wider at the base, more than twice longer than broad, and incised at the apex. Median segment almost perpendicular, transversely striolated; the central keels not reaching to the apex and forming an elongate triangle, with a smooth ovate fovea at its apex; metapleuræ striated. A line on the pronotum (narrowed in the middle) the tubercles, tegulæ, two large square marks on the scutellum, the metanotum, the lateral laminæ, and the apex of the central mucor, pale yellow. Scutellum keeled down the centre. Abdomen minutely punctured, shining, a large fascia on the first segment, an irregular band, narrowed and interrupted in the middle on the second, and a complete band on the third and fourth segments, pale yellow; pygidial area punctured, covered with stiff fulvous, glistening depressed bristle-like pubescence, and sharply pointed at the apex. Ventral segment with scattered punctures, shining. The recurrent nervure is received considerably before the middle of the radial cellule, and is straight, not oblique. Length nearly 7 mm.

OXYBELUS FULVOPILOSUS, *sp nov.* (Pl X., f. 23.)

Head closely punctured. Covered with a fulvous, the clypeus and cheeks sparsely with silvery pubescence. Eyes slightly converging towards the clypeus; margined; the hinder ocelli separated from each other by twice the length they are from the eyes. Clypeus shining, bluntly and distinctly keeled in the middle. Antennæ with the flagellum fulvous beneath; the third joint a little longer than the fourth and attenuated at the base. Thorax closely punctured, covered with a fulvous silvery pubescence, that on the sternum longish. Collar transverse, the sides obliquely truncated; the mesosternal furrows not very distinct; the lateral laminæ of the metanotum bluntly triangular at the apex; the central convex above, nearly twice longer than broad, and somewhat roundly incised at the apex; median segment with a semi-oblique slope, shagreened, the central keels joining before reaching the apex of the segment and united to the lateral by three keels; the base with some irregular keels; the metapleuræ irregularly striated. Abdomen finely punctured, a large bright yellow macula on the sides of segments one to five, the apical segments punctured, densely covered with stiff rufo-fulvous bristle-like pubescence; the apex rounded. The recurrent nervure is straight and is received a little beyond the basal third of the radial cellule. Length nearly 7 mm.

B. *Thorax without laminæ.*

OXYBELUS BELLUS, *sp. nov.*

Black, closely punctured and covered with a pale fulvous pubescence, a narrow line on the pronotum, the tubercles, a large broad mark below them, the tegulæ in part, a mark on each side of the scutellum, the metanotum, a large mark on the side of the basal two segments, a narrower one on the following two and the legs, clear red; the anterior coxæ black, the four anterior lined with black above, the posterior black, except at the base and apex. Front excavated, densely covered with longish silvery-fulvous hair; this being also the case with the clypeus. Ocelli in a curve, the hinder separated from the eyes by the length of the second antennal joint. Mandibles rufous and yellow, black at the apex. The punctuation on the head is rugose. Thorax strongly punctured; the scutellum with scattered punctures; the metanotum impunctate and without laminæ; median segment reticulated. Abdomen closely punctured; the apical segments covered with longish pale silvery hair; the pygidial area a little longer than broad, rounded at the apex. The anterior tibiæ incline to yellow behind; the legs covered with a short close white pubescence; tibiæ serrate. The eyes are rounded inwardly, converging towards the apex. Wings hyaline, the nervures fuscous; the recurrent nervure is received slightly beyond the middle of the radial cellule. Tibial spurs slender, curved, reaching to the middle of the metatarsus. Abdominal segments lined with silvery pubescence. Length nearly 8 mm.

May be known from *O. argenteolineatus* and *nitidus* by the reddish legs and by the longer and thinner calcaria.

OXYBELUS NITIDUS, *sp. nov.*

Head smooth, shining, covered with a silvery pubescence, very densely on the clypeus and cheeks, the front excavated in the middle, glabrous. Ocelli in a curve, the hinder separated from each other by only a little greater distance than they are from the eyes. A curved, oblique shallow depression runs from the outer ocelli to the eyes. Clypeus broadly convex, yellow; mandibles yellow, piceous-red at the apex, eyes hairy. Antennæ densely covered with silvery pubescence; the scape yellow, the third and fourth joints equal. Thorax smooth, shining, covered with soft pale pubescence; the pronotum transverse, rounded at the sides. Mesopleural furrow crenulated; medium segment at the base, with short stout keels, bounded by a narrow keel which proceeds to the apex, the sides of the segment being also keeled. Metapleuræ excavated at the base, smooth and shining. There is a small oblong fovea on the metapleuræ behind, a line on the pronotum, tegulæ, tubercles, a large mark below them, a mark on either side of the scutellum, a line on its hinder edge at the sides behind, and a narrower line in the same place on the metanotum, pale yellow. Abdomen shining, smooth; a small mark on the side of the first segment, a large one on the second, none on the third, a large broad one on the fourth, and a smaller one on the fifth, pale pellow; pygidium reddish at the apex, densely covered with soft pale pubescence and punctured. Length 7 mm.

OXYBELUS ARGENTEOLINEATUS, *sp. nov.*

Head strongly punctured, closely covered (the vertex sparsely) with a white silvery pubescence; the mandibles yellow at the base; deeply furrowed. Front ocellus in a shallow depression; an elongated fovea on the outer side of the posterior near the eyes. Antennæ black, shortly pilose, stout; the third joint distinctly longer than the fourth. Thorax close punctured, the pleuræ almost rugosely; the pronotum above, the tubercles and metanotum yellow. Pronotum above transverse, projecting, the sides obliquely curved. Metanotum without laminæ. Median segment short, semi-perpendicular; the base with short stout keels, becoming longer towards the middle, margined, and with two keels which run down to the apex of the segment, converging as they do so. Metapleuræ coarsely shagreened, the base hollowed, shining, and impunctate. Abdomen punctured; the segments lined densely with silvery pubescence, which becomes narrowed in the centre; pygidial area densely covered with stiff rufofulvous depressed pubescence. Legs densely covered with silvery pubescence; the tibiæ more or less lined with black behind; the short stumpy teeth on the hind tibiæ rufous. The recurrent nervure is received in the middle of the radial cellule, and is slightly curved and oblique. Length 6 mm.

OXYBELUS LEWISI, *sp. nov.*

Black, densely covered with a short silvery pubescence; the punctuation close, moderately strong; the mandibles, tubercles, tegulæ in part, two elongated marks on the scutellum, metanotum, a line running from the scutellum and metanotum to the wings, a lateral mark on abdominal segments 1—5 and the knees, tibiæ and tarsi in front, yellow, wings clear hyaline, the nervures pale fulvous. Ocelli in a curve; the hinder separated from the eyes by the length of the third antennal joint; eyes rounded inwardly, converging beneath; the pubescence on the head in front long and dense; the punctuation finely rugose. Scutellum above flat, laterally obliquely margined; the apex of metanotum rounded, without laminæ. Median segment above laterally obliquely, in the centre below, transversely striolate, the striations wide apart and stout; shining, impunctate, metapleuræ finely rugose, obliquely striated; the spine at the base of the median segment stout, acute. Abdomen shining, aciculate; densely pilose; pygidial area acutely pointed, the pubescence fulvous at the apex, dense; the base of the petiole depressed, striolated. The recurrent nervure is received somewhat beyond the basal third of the radial cellule. Length 6 mm.

Hab. Nugata, Ceylon (*George Lewis*).

Explanation of Plates.

PLATE IX.

FIG.

1. *Tachytes Rothneyi*, Cam.
2. *Notogonia luteipennis*, Cam.
3. *Tachytes tarsatus*, Smith.
4. *Ammophila violaceipennis*, Cam.
5. *Notogonia erythropoda*, Cam.
6. *Gastrosericus Wroughtoni*, Cam.
7. *Sphex xanthoptera*, Cam.
8. *Piagetia fasciatipennis*, Cam.
9. *Rhinopsis ruficornis.*
10. *Sphex diabolicus*, Sm. ♂ organs.
11. *Ammophila tyrannica*, Cam.
12. *Sphex aurulenta*, ♂ organs.
13. *Nysson rugosus*, head, 13^a antenna.
14. *Gorytes orientalis*, head, 14^a antenna.
15. *Do. amatorius*, head, 15^a antenna.
16. *Ampulex compressa*, Fab.
17. *Piagetia ruficornis*, Cam. face.
18. *Nysson erythropoda*, head, 18^a antenna.

PLATE X.

FIG.

1. *Stizus reversus*, antenna ♂.
2. *Cerceris viligans*, head, (*a*) apical ventral, (*b*) apical dorsal segment.
3. *C. rothneyi*, head, (*a*) apical ventral, (*b*) dorsal segment.
4. *C. instabilis*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.
5. *C. pulchra*, head, (*a*) apical ventral, (*b*) dorsal segment.
7. *C. tristis*, head, (*a*) apical dorsal, (*b*) ventral segment.

7*. *C. vischnu*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.

8. *C. novaræ*, head, (*a*) apical ventral, (*b*) dorsal segment.
9. *C. Wroughtoni*, head, (*a*) apical ventral, (*b*) dorsal segment.
10. *C. dentata*, mesosternum.
11. *C. sulphurea*, head, (*a*) apical ventral, (*b*) dorsal segment.
12. *C. tetradonta*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.
13. *C. pentadonta*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.
14. *C. orientalis*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.
15. *C. nebulosa*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.
16. *C. humbertiana*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.
17. *C. hilaris*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.
18. *C. flavopicta*, head and clypeus, (*a*) apical ventral, (*b*) dorsal segment.
19. *Philanthus depredator*, head, (*a*) apical ventral, (*b*) dorsal segment.
20. *Crabro odontophora*, (*a*) fore leg, (*b*) hind leg.
21. *Oxybelus robustus*, squama.
22. *Do.* *canescens*, squama.
23. *Do.* *fulvopilosus*, squama.
24. *Do.* *squamosus*, squama.

[*Physical and Mathematical Section.*]

Ordinary Meeting, 23rd October, 1889.

JAMES BOTTOMLEY, D.Sc., President of the Section, in the Chair.

Moved by Mr. J. A. BENNION, M.A., seconded by Mr. WM THOMSON, F.C.S., and resolved that a copy of the following resolution be forwarded to the family of the late Dr. Joule :—

"The members of the Physical and Mathematical Section of the Manchester Literary and Philosophical Society beg to tender to Mr. J. A. Joule and the other members of the family their sincere condolence in the loss which they have recently sustained by the death of the late Dr. James Prescott Joule. Dr. Joule was a member and a former President of the Section, and the members feel keenly the loss of one whose eminence in science and kindly interest in the work acted as a powerful stimulus to its advancement and success."

Mr. J. A. BENNION, M.A., explained the Gerard-Barre hydraulic sliding railway shown at the recent Paris Exhibition, and also the process of making a fibre resembling silk from sawdust, as shown in the Forestry Section of the same Exhibition.

Dr. BOTTOMLEY read a paper entitled "Note on the Rate of Dissolution of Solids."

[*Physical and Mathematical Section.*]

Ordinary Meeting, 20th November, 1889.

JAMES BOTTOMLEY, D.SC., President of the Section, in the Chair.

Mr. J. A. BENNION, M.A., was elected a Vice-President of the Section.

Mr. WM. THOMSON, F.C.S., described a new Hygrometer invented by M. Mithof, and stated that he had himself been working for some time at the problem of producing a hygrometer, which should indicate the amount of vapour of water in the atmosphere of weaving-sheds, independently of temperature.

[*Physical and Mathematical Section.*]

Ordinary Meeting, February 26th, 1890.

JAMES BOTTOMLEY, D.Sc., President of the Section, in the Chair.

Mr. T. W. BROWNELL, F.R.A.S., and Dr. ALEXANDER HODGKINSON were elected members of the Section.

Dr. BOTTOMLEY called the attention of the Section to a method of integrating Differential Equations, and read a note on the integration of a partial differential equation.

Mr. WM. THOMSON, F.C.S., made some observations on the apatite-bearing lodes and apatite pockets in Norway which he had recently examined.

[*Physical and Mathematical Section.*]

Annual Meeting, March 20th, 1890.

JAMES BOTTOMLEY, D.Sc., President of the Section, in the Chair.

The Treasurer's accounts for the year 1889–90 were presented, and showed :—Balance from last year £5. 0s. 2d., cash received during the current year £3. 1s. 7d., making a total of £8. 1s. 9d., against which were payments during the current year £4. 2s. 2d., leaving a balance in favour of the Section of £3. 19s. 7d.

It was moved by Mr. WM. THOMSON, seconded by Mr. FARADAY, and resolved :—"That the Treasurer's accounts be received and passed."

The following gentlemen were elected officers of the Section for the ensuing year :—

President :—JAMES BOTTOMLEY, B.A., D.SC., F.C.S.

Vice-Presidents :—WM. THOMSON, F.R.S. Ed., F.C.S., F.I.C.; J. A. BENNION, M.A., Barrister-at-Law.

Secretary :—T. W. BROWNELL, F.R.A.S.

Treasurer :—JOHN ANGELL, F.C.S., F.I.C.

It was moved by Mr. J. A. BENNION, seconded by Mr. WM. THOMSON, and resolved :—

That Rule I. be altered so as to read :—"That the object of the Section be the promotion of Physics and Mathematics."

The following constitute the Section :—

Members :—JOHN ANGELL, F.C.S., F.I.C. ; JAMES BOTTOMLEY, B.A., D.SC., F.C.S. ; T. W. BROWNELL, F.R.A.S. ; F. J. FARADAY, F.L.S., F.S.S. ; A. HODGKINSON, M.B., D.SC. ; WM. MATHER, M.P. ; WM. THOMSON, F.R.S. Ed., F.C.S., F.I.C. *Associate* :—J. A. BENNION, M.A.

[*Physical and Mathematical Section.*]

Ordinary Meeting, 30th April, 1890.

JAMES BOTTOMLEY, D.SC., President of the Section, in the Chair.

Dr. BOTTOMLEY remarked on Professor Pickering's paper on the Composition of Solutions, read before a recent meeting of the Chemical Society, and expressed disagreement from the Professor's mathematical treatment of the subject.

Annual Report of the Council, April, 1890.

The number of members on the roll on the 31st March, 1890, is 141, or 9 more than at the corresponding period of the previous year. The Society has lost one ordinary member by resignation, and four by death; and fourteen new ordinary members have been elected. The Council has much satisfaction in stating that for the first time for some years the numbers have increased, but would point out that a considerable further extension in the membership of the Society is greatly to be desired.

The Treasurer reports that the various accounts show balances at the credit of each on the 31st March, 1890, and that the cash balance lying at the bank at the same date is £277. 5s. 10d., or £58. 2s. 4d. less than on the 1st April, 1889. The tabulation of the revenue and expenditure of the Society is shown by the accompanying balance sheets, the figures of the previous session being appended for comparison.

The several items of expenditure included therein need little explanation. A selection of a portion of the apparatus used by the late Dr. Dalton in his historic investigations has been displayed in suitable glass cases affixed to the walls of the Library, at a cost of £24. 14s. 0d. In the publishing account will be noticed the reappearance of a former item, viz., the honorarium of £50. 0s. 0d. for editing the Society's publications; in asking the Editor's acceptance of this sum, the Council put on record its grateful acknowledgements of the able and gratuitous services rendered to the Society from the time when Mr. F. J. Faraday first undertook the oversight of its publications. The Library has had spent upon it, for binding books, the sum of £52. 2s. 8d., which is £17. 4s. 6d. in excess of the amount of the special subscriptions of the members; this last-named sum has been transferred to the general account, so as to close the Binding Fund account.

The Societies which continue to be accommodated on the premises are the same as last year, viz.: the Manchester Geological Society; the Manchester Medical Society; the Manchester Photographic Society; and the Manchester Scientific Students' Association.

The Librarian reports that there has again been an increase in the number of volumes received from other Societies during the year; this arises from the addition of fifteen Societies to those with whom we exchange publications. About 200 volumes have been issued to members during the year, but this number does not at all represent the number of books consulted.

Among recent additions to the Library is a complete set of the Manchester Court Leet Records, 12 volumes. Authors' presentation copies have been received from Prof. Michael Foster, M.A., F.R.S., "A Text Book of Physiology," Vols. I. and II.; Mr. Walter R. Skinner, "The Mining Manual, 1888:" Prof. W. G. Farlow, "Marine Algæ of New England and adjacent Coasts," and several papers; Professor Cayley, "Collected Mathematical Papers," Vol. II.; The Trustees of James Henry, "Æneidæ," Vols. III. and IV.; Mr. F. Nicholson, "Sundevalls' Tentamen"; Sir J. W. Dawson, "Palæozoic Gymnosperms;" Sir H. E. Roscoe and Prof. C. Schorlemmer, "Treatise on Chemistry," Vol. III., Part 2, new and revised edition; Professor J. C. Adams, "Appendices;" Dr. Werner Siemens, "Wissenschaftliche und Technische Arbeiten;" Prof. C. Schorlemmer, "Geschichte organ. Chemie," "Ausführliches Lehrbuch der Chemie," Vol. II., Part 2, and Vol. IV., Part 4; Dr. William Sharp, F.R.S., "Essays on Therapeutics, &c;" the University of Cambridge, "Astronomical Observations," Vol. XXII.;

and a considerable list of official publications of the American, Australian, Mexican, Canadian, British, and other Governments.

Appended to this report is a list of the Societies and other public bodies from whom publications are received and of periodicals also regularly added to the Library, by exchange or purchase. The Council would point out that lists of the additions to the Library are now regularly published on the covers of the parts of the *Memoirs and Proceedings* in order that members may be informed of the new publications available for reference as speedily as possible. The Council has decided to issue the parts of the Society's own *Memoirs and Proceedings* to corresponding Societies and institutions, and to honorary and corresponding members, immediately on publication—instead of in the completed form at the end of the year as hitherto—in order that the papers read before the Society may be promptly brought under their notice.

The Council has had under consideration the questions of preparing a catalogue of the Library, of arrears of binding, and of printing the index to the *Proceedings* and *Memoirs*, 1st, 2nd and 3rd series, referred to in last year's report, and have received an estimate from the Librarian as to the cost. The Council hope that these *desiderata* may be proceeded with at an early date.

The Council has considered the whole question of the value of Sections to the Society and has received a report from a special committee (appointed to enquire into their relations to the parent Society, their constitution, rules, and system of electing Associates), to the effect that the existence of the Sections has been advantageous to the parent Society, and has tended to increase the number of its members. The Council therefore recommends the members to continue the system of electing Associates of Sections, by the usual annual resolution.

The losses, by death, of the Society during the Session are:—Ordinary members, Dr. J. P. Joule, F.R.S., Mr. John Dale, F.C.S., Mr. Daniel Adamson, M.Inst.C.E., and Mr. Andrew Knowles; Honorary members, MM. G. A. Hirn, H. D. Buys Ballot and G. H. Halphen. References to Dr. Joule's death and the initiation of a Memorial to him by the Council will be found in the current volume of the *Memoirs and Proceedings*, pp. 5, 55, and 112, and a memoir of his life is in preparation by the President. Obituary notices of MM. Hirn and Buys Ballot have also appeared in the current volume of *Memoirs and Proceedings*, pp. 159 and 167.

By the death of JOHN DALE technical chemistry has lost one of its foremost pioneers, who was acknowledged as such on the Continent and in America as well as in the United Kingdom. Dale was a born chemist; a man may be taught chemistry, but he never will distinguish himself as a chemist, if he does not possess an enthusiasm for the science, and this Dale had in the highest degree. He was born at Birmingham, on the 11th of May, 1815, and educated in his native town, and in Warwick. In the latter place he had a schoolmaster of whom he always spoke with great admiration. This excellent man took his pupils out for a walk, asking questions on all natural objects they came across, and at the same time giving them instructions. To this original and attractive mode of teaching, Dale attributed much of the acuteness and power of observation by which he was distinguished. After his school days, Dale was apprenticed to a chemist and druggist at Denbigh, and from there he moved to Rhyl, where he had access to a number of chemical and pharmaceutical works, which enabled him to prosecute his studies. We next find him in Manchester as assistant to Mr. Ansell, a member of the Society of Friends and an acquaintance of Dalton, with whom Dale also soon became acquainted, and from being his pupil he became his friend. Following the example of his master, Dale commenced a course of lectures on Chemistry, going to all the principal towns of Lancashire. He illustrated his lectures with many original experiments, which he performed most skilfully, and received from Dalton especial commendation and compliments on his successful undertaking. He often related with great humour, how after a lecture in a school-room, he gave orders to have the room locked until he could remove his apparatus and chemicals. The schoolmaster being struck with the combustion of phosphorus in oxygen, could not resist the temptation to carry off a piece of this dangerous body, which had very unpleasant consequences, as he put it in his pocket for taking it home. After a short removal to Altrincham, Dale returned to Manchester, where he took a shop in St. Mary's Gate, and during this period he made the acquaintance of Mr. T. Roberts, with whom he afterwards went into partnership. It was at this time that he made his first discovery. In 1825 Faraday had been requested by the Portable Gas Company to find out why the gas, which was obtained by the distillation of oil and pumped into copper cylinders under pressure, lost much of its illuminating power when kept for some time. Faraday found the cause to be the condensation of some of the gas to a liquid, which he examined and thus discovered two new hydrocarbons. One of these, which he called bicarburet of hydrogen, was in 1834 obtained by Mitscherlich from benzoic acid and named benzine by him, on the assumption that it was derived from benzoic acid simply by the abstraction of carbonic acid. To this Liebig objected, and changed the name of the empyremnatic oil obtained by distilling benzoic acid with lime into benzol, because the ending *ine* reminded one of quinine or strychnine with which it had nothing in common. He adds that it would have been better to have retained Faraday's name, as this oil had no closer connection with benzoic acid than with train oil or coal from which it also might be obtained. How Liebig became acquainted with the fact that benzene is formed by the dry distillation of coal is not known, as his pupil Hofmann, who obtained it in 1845 from coal-tar observes: "It is frequently stated in memoirs and text-books that coal-tar oil contains benzol. I am, however, unacquainted with any research in which this question has been investigated."

The writer, taking an interest in this question, asked Mr. Dale if he could give him any information, and thus elicited the following interesting facts. About 1834, at the time when Mitscherlich had converted benzol into nitrobenzol, the distillation of coal-tar was carried out on a large scale in the neighbourhood of Manchester; the naphtha which was obtained being employed for the purpose of dissolving the residual pitch and thus obtaining a black varnish. Attempts were made to supplant wood-naphtha, which at that time was used in the hat factories at Gorton for the preparation of "lacquer" by coal-tar naphtha. The substitute however did not answer, as the impure naphtha gave off on evaporation so unbearable a smell, that the workmen refused to employ it. It was also known about 1838 that wood-naphtha contained oxygen, while that from coal-tar did not, and hence Mr. Dale attempted to convert the latter into the former, or into a similar body. By acting on it with sulphuric acid and nitre, he obtained a liquid possessing the smell of bitter almonds, which, however, he did not examine any further. This was done by Mr. John Leigh, who, at the meeting of the British Association held in Manchester, 1842, exhibited a considerable quantity of nitrobenzol and dinitrobenzol before the Chemical Section, Dalton being the president. Thus, for the first time, it was proved that coal-tar contains a considerable quantity of benzol. Liebig was in England at this time, and, if the writer is not mistaken, attended the Manchester meeting, and when he in 1834 said that benzol could be obtained from coal, he most probably arrived at this conclusion because the products of the distillation of oil are very similar to those obtained from coal.

From the shop in St. Mary's Gate, Mr. Dale went as manager to a print-works in Ardwick, and the knowledge of printing and dyeing which he thus acquired became of the greatest use to him afterwards.

In the year 1852 he started, with Mr. Roberts, the well known chemical works at Cornbrook, and soon introduced many new processes of manufacture. The paper-hanging trade began to develop at this time, and Dale replaced the older colours by much brighter and finer ones, such as a much superior class of chrome-yellows and of lakes, as the compounds of organic colouring matters with certain metallic oxides are called. Such lakes, with a base of alumina, had for a long time been made from sappan-wood, peach-wood, &c.; but they had several disadvantages, which restricted their use in practice, not being permanent and having little body. Moreover, they were gelatinous and cracked on drying. Mr. Dale avoided this by using oxide of tin as a base, and thus produced lakes which, owing partly to their physical condition, and partly to their chemical composition, possessed the requisite degree of permanency and intensity of colour. Of these a beautiful scarlet lake from bar-wood may be specially mentioned, because it is obtained by a method which could only have been devised by a practical calico printer. The colouring matter of bar-wood is very slightly soluble in water; the ground wood is, therefore, simply treated with boiling water and the required quantity of oxide of tin is added, which absorbs at once the colouring matter as soon as it gets into solution, and thus more and more dissolves and combines with the oxide until the lake has acquired the requisite intensity of colour and the wood is exhausted.

Dale's greatest achievement was, however, the manufacture of oxalic acid from saw-dust. Up to this period it was obtained by oxydising sugar or starch with nitric acid. Gay-Lussac had already shown in 1829, that this acid is also produced by heating vegetable fibre, sugar, starch, gum, and tartaric acid with caustic potash. Neither scientific chemists nor practical men attended to this subject until Mr. Dale took it in hand. In his attempt to do so, he was met with a number of serious obstacles, chiefly of a practical nature. These, however, he, by dint of uncommon ingenuity, and by the application of an amount of perseverance of which, perhaps, but few men are capable, succeeded in overcoming, and the process was then soon in full and successful operation at Messrs. Roberts, Dale, and Co.'s works, at Warrington. None of the scientific chemists who attended the Manchester Meeting of the British Association in 1861, when Kekulé was his guest, will forget the day when Mr. John Dale conducted them over the works and explained the process to them in his peculiarly lucid manner. The only practical suggestion which Gay-Lussac had made consisted in the proposal to convert cream of tartar by his method into oxalic acid. At that time tartaric acid was cheaper than oxalic acid, and the suggestion might, therefore, under the circumstances of the time, have proved of some practical value. It was evident, however, that for the purpose of ensuring success a cheaper material had to be chosen. Dale found woody fibre in the shape of saw-dust to answer perfectly. Gay-Lussac had stated that potash might be replaced by soda; Mr. Dale, however, found that saw-dust yields hardly any oxalic acid when fused in the soda. On the other hand, potash was found to be too expensive, and the process would not pay. He overcame the difficulty by using a mixture of two equivalents of soda to one of potash, which answers not only as well as potash alone, but has the great advantage, that an almost insoluble sodium oxalate is formed, and thus the excess of alkali and all the bye products can be easily separated. For a successful operation of the process it was necessary to bring the recovered mixture of the alkalis quickly into work again, which could be only done by having a rapid method for determining their relative amount. A series of experiments led Dale to a very simple method of analysis. A given volume of the solution is neutralized with tartaric acid of known strength, and then an equal volume of the latter is added in order to convert the alkalis into the bitartrate, that of potash separating out and the separation is quickened by stirring the liquid well. In order to get good results the solution of the sodium bitartrate must be nearly saturated or stand at 6° Tw. The cream of tartar which separated out was filtered off, slightly washed with water, and filtrate and precipitate were then separately neutralised with a standard solution of caustic soda. Thus the percentage of the two alkalis could be ascertained within half an hour. Dale, as usual, did not publish this method, and many years afterwards it was rediscovered by Mohr.

The same was the case with another analytical method which Dale devised for estimating the amount of colouring matter in indigo, which is called indigo blue and has the characteristic property of being converted, by reducing agents, into indigo white, which is soluble in alkalis. On exposing this solution to the air, it rapidly absorbs oxygen, and indigo blue is reprecipitated. This reaction is made use of in indigo dyeing, fine indigo being brought together with water, green vitriol, and slaked lime. A careful examination of this subject by Dale showed that a certain quantity of indigo blue undergoes such a change that it is not reprecipitated, and in employing this reaction as an analytical method, this has to be taken into account. By a series of elaborate experiments Dale found that by working under strictly the same conditions, the loss is quite constant, and thus he discovered a method by which the value of indigo can be quickly and exactly determined. This method was communicated to the writer by Mr. Dale and published in the second edition of Muspratt's dictionary.

Ullgren later came to the similar conclusions as Dale and published a paper on the subject in Liebig's *Annalen.*

Other analytical processes were devised by Dale, as that for estimating tin by potassium dichromate, and his fertile and resourceful mind led him to many other improvements in technical and analytical chemistry. In the year 1858 Perkin discovered aniline-purple, or mauve, the first aniline colour which appeared in the market. He obtained it by the action of potassium dichromate on sulphate of anilin. Dale, in conjunction with Caro, endeavoured to find an equally effective oxidising agent, and both having a practical acquaintance with calico-printing, hit upon one which a purely scientific chemist would probably not have thought of. They employed a mixture of copper sulphate and common salt. By using this, however, acid was liberated which interfered with the production of the colouring matters, and the further improvement of the process which Dale devised was a judicious addition of an alkali. At the same time a useful black pigment was produced, which is the more interesting as it may be said to have led to the discovery of aniline-black by Lightfoot, to whom the reaction was known.

Among the artificial colouring matters which to-day are largely manufactured, the class of the azo-colours is one of the most important. Of these in 1863 only aniline-yellow was known. Dale, in conjunction with Caro and Martius, soon brought two new ones, known as Manchester Yellow, or Martius Yellow, and Manchester Brown, or Bismark Brown, which are still specialities of Messrs. Roberts, Dale and Co. Many other novel and original processes were devised by Mr. Dale, who was always ready to place his large and unique experience at the disposal of his friends, and among these the writer has to thank him for much and most valuable information. During the last four or five years his health had been failing, but his interest in the later development of technical and pure science never flagged. He died 31st May, 1889, and thus another link of the chain connecting the younger generation of chemists with the illustrious Dalton has been broken.

The name of DANIEL ADAMSON, which will be long remembered in connection with the Manchester Ship Canal, is also assured a place amongst distinguished engineers by the part which he took in the development of steam engineering and the use of steel. Born at Shildon, Durham, in 1818, Adamson became apprenticed, when seventeen years old, to the celebrated T. Hackworth, at the Stockton and Darlington Railway. After serving here for six years, he was appointed managing draughtsman and superintendent engineer to the same Company. This post he held until 1847, when he became manager of the Shildon works, also belonging to this Company. In 1849 he left the service of the Stockton and Darlington Railway, and after holding for a short period the position of manager to the Heaton Foundry, Stockport, he, in 1851, commenced business on his own account as Engineer and Boiler Maker, at Newton Moor Iron Works, near Manchester. About this time he inaugurated a series of reforms and improvements in the construction and manufacture of steam boilers, with which his name has become associated. The first of these consisted in the introduction of the flanged seam for the flue tubes, to replace the ordinary lap ring seam which was then generally used. According to Adamson's method, the flue tubes are made in welded sections, the ends of which are provided each with a flange having a radius of one inch to one and a quarter inches in the bend. Between the two flanges a hoop of flat plate is placed, and the seams are riveted up by rivets passing through the flange of one ring, the hoop and the flange of the next ring. The seam thus formed not only adds enormously to the strength of the tube in resisting collapse, but it also completely overcame the difficulties which had been previously experienced through the effect of the expansion of the flue tubes bulging the end plates Adamson in 1852 patented this device, which in later years has been generally adopted, and still forms one of the features of Lancashire boilers.

Adamson early recognised the part which steel was destined to play in engineering construction, and successfully carried through its application in the manufacture of boilers. It appears that his application of steel began about 1857 (*Proceedings Iron and Steel Institute*, 1879, p. 113), in making a locomotive for Messrs. Talabot, of Paris, to haul iron-stone from the Bonner mines in Algeria to the coast. Only puddled steel could then be got sufficiently ductile, and that was produced at the Mersey Steel and Iron Company's works at Liverpool. About that time Mr. Bessemer patented his famous process of steel manufacture, and Mr. Adamson at once prepared to use the new material for boiler making, and in 1860 he made the first Bessemer steel boilers for Messrs. Platt Bros., of Oldham. These boilers were 30 feet long by 7 feet 6 inches diameter, and were made of plates only $\frac{5}{16}$ inch thick for a working pressure of 80lb.; no better proof of the thoroughness with which Mr. Adamson completed his task can be given than the fact that these identical boilers have remained in use to this day. But in spite of Adamson's strong advocacy of the new material, it was very little used by others for many years, chiefly because it was found too unreliable, owing to want of knowledge in the choice and treatment of the metal. Originally, steel of a tensile strength of forty tons to the square inch was used, but complete success was not obtained until a milder variety having a tensile strength of thirty to thirty-two tons, with 20% elongation, was adopted, whereas now-a-days, in the best practice, engineers are content with a strength of 24 to 28 tons per sq. inch, and an elongation of not less than 20% in a length of ten inches. Steel plates made by the Bessemer or Siemens process, as now used, are not only stronger, but more uniform in quality than iron, they are practically not liable to blistering or lamination as were even the best iron plates, and they are tougher and more ductile and even less liable to deterioration in work than iron plates. In all first-class boiler work steel plates are now practically used to the exclusion of iron.

When steel was first used, it was found that the plates were seriously damaged by the operation of punching the rivet holes, and, to overcome this difficulty, Adamson in 1862 introduced the method of drilling these holes, to avoid distressing the plates. On Mr. Adamson's plan, the plates are bent to their final form, and the holes are drilled through the plates when in the position they will occupy in the finished state. The plates are then taken apart, the burrs formed in drilling removed, and the plates and seams are riveted up. In this way the holes fall quite true and fair when brought together, thus avoiding all such drifting as was customary with punched holes to the detriment of the plate. The holes also being true, each rivet completely fills its hole, and takes up its proper proportion of the stress, whereas in the rough and irregular surfaces of punched holes, some rivets might be taking an undue share of the strain, thus causing rupture at a point below the strength of the seam taken generally. Thus the seam is strengthened and made more reliable, it is less liable to leakage, the material is better utilised, and the work is altogether better and more neatly finished.

These three improvements which Daniel Adamson has been prominent in bringing forward are the characteristics of the modern stationary type of boiler in this country, which is constructed for working pressures up to 200lbs. per square inch, and it would appear that Mr. Adamson has scarcely received a proportionate amount of credit for these important achievements. Moreover when Adamson commenced boiler-making the manufacture of stationary boilers was carried on upon the rudest rule-of-thumb methods, and Adamson was the first to bring system into the construction and manufacture of these boilers by proportioning all parts with a careful regard to the forces to be met. In this way he not only greatly reduced the weight of boilers in proportion to their strength, but having recognised the economic advantages of using steam at a high pressure, he set about to construct boilers for pressures greatly in excess of those then in vogue, and, as early as 1855, he had made a boiler and engine which worked successfully with a steam pressure of 150lbs. Ever since the theory of multiple expansion was propounded, he was a firm believer in this principle, and in 1861, he had actually built a triple expansion engine, whilst in 1873, he made the first quadruple expansion engine ever constructed.

In the investigation of the metallurgy of iron and steel, Adamson took a leading part, and few men could boast of a more intimate acquaintance with the properties of these metals, based upon long experience. Some idea of the amount of labour Mr. Adamson bestowed upon the investigation of the mechanical properties of iron and steel, may be formed from his own remark that up to 1879 he had tested from 30,000 to 40,000 specimens of steel suitable for boiler plates. Not only were his tests more thorough and complete than any which had preceded them, but he also made a chemical analysis of all samples tested, and was amongst the first to make practical use of chemical analysis for ascertaining the mechanical properties of iron and steel. Adamson proved by his experiments that it was possible to obtain qualities of mild steel which would be superior to the best iron for bridge building and other structures, as well as for boiler work, and in this way he aided materially in bringing about the more extended use of steel in place of iron. In the early days of steel great difficulty was also experienced in welding the new material, and Adamson was the first to point out the conditions under which successful welding was possible.

Mr. Adamson also took an extremely active part in opening out the Lincolnshire iron fields, and he was the first to erect a furnace at Frodingham, in 1866, depending entirely for its supplies upon ores found in the district. The greatest difficulty was, however, experienced in working the ore, as it could not be fused at the usual temperature of the blast furnace, owing to the presence of a large quantity of lime mixed with the ore, and a want of silica and alumina. This experience was gained at a great cost, but the difficulty was ultimately overcome by the addition of Lincoln siliceous ore, which is combined with a large quantity of alumina, and these works have since been very prosperous.

It yet remains to refer to the crowning work of Adamson's life, which consisted in rescuing the Manchester Ship Canal scheme, and rendering it a practically possible undertaking. It is a thrice-told story how Adamson, by force of argument, succeeded in arousing the enthusiasm of the teeming millions of Lancashire workers in support of the great scheme, how bravely he fought the Parliamentary battle in the face of the opposition of the greatest vested interests in the Empire, how the reverses which would have sufficed to paralyse the powers of less sturdy men only served to spur Adamson on to renewed efforts, and how he finally led the scheme to triumphant victory.

In the great popular agitation which carried the Ship

Canal Bill, Adamson was the chief actor, but finding himself less successful in dealing with the financial difficulties he retired, leaving it to others to carry out the work. In the course of a few years this great monument to the ability and energy of Mr. Adamson will be completed, and it is matter of the deepest regret that he should not have been spared to see the accomplishment of the great work.

Mr. Adamson took an active share in the work of the leading technical societies, at the meetings of which he was a regular attendant and frequent speaker. In 1877 he was elected a member of the Institute of Civil Engineers. In 1888, the Iron and Steel Institute gave expression to their high opinion of his merits by electing him their President, and in the same year he was presented with the Bessemer Gold Medal of that body. He was elected a member of the Manchester Literary and Philosophical Society in 1881, under the Presidency of Mr. Binney.

Mr. Adamson died on January 13th, 1890, after a lingering illness, at his residence, the Towers, Didsbury, near Manchester.

Mr. ANDREW KNOWLES died suddenly at his residence, Swinton Old Hall, on March 12th, 1890, being then in his sixtieth year. He occupied a foremost position in connection with the coal trade, being chairman and managing director of the great colliery company known as Messrs. Andrew Knowles and Sons, Limited, for a period of sixteen years, that is, from the formation of the Company until his death. Though a Justice of the Peace for Lancashire, his activity was mainly commercial, and he took little or no part in public affairs, beyond giving liberal financial aid to religious and social movements in the district where his life was spent. He was elected a member of the Society in 1862, under the presidency of Mr. Binney. Though he read no papers before the Society he was a generous donor to its funds, amongst other contributions being one of £100 to the Centenary Fund for the enlargement of the Society's house.

At our last Annual Meeting M. HALPHEN was elected one of our honorary members, and we have already to record his premature death. GUSTAVE HALPHEN was born at Rouen on the 30th of October, 1844, and, after a brilliant career as a student at the École Polytechnique, became an officer in the Artillery. He served with great distinction in the war of 1870, especially after he was attached to General Faidherbe's Army of the North. He received the decoration of the Legion of Honour from the General after the battle of Pont-Noyelles, and his management of his battery in the battle of St.-Quentin is specially mentioned in Faidherbe's "History of the campaign of the army of the North." Halphen continued in active service till 1873, when he became attached as teacher and examiner for admission to the École Polytechnique. In 1886, he became major, and joined his regiment; and was on the point of becoming lieutenant-colonel when he died, at the age of 44, on the 23rd of May, 1889. Halphen's mathematical publications began in 1869, and he published more than a hundred memoirs on Algebra, the Higher Geometry, the Theory of Numbers, and Elliptic Functions. All his works have shown a uniformly high merit, and his name will be remembered in connection with every subject that he handled. The esteem in which his work is held by contemporary analysts has been well expressed by Brioschi, himself one of the greatest, in announcing his death to the Academy dei Lincei of which Halphen was an honorary member, and to which reference may be made for fuller details.

The following papers and communications have been read, or will be read before the close of the session, at the ordinary meetings of the Society :—

OCTOBER 1st, 1889.

An Account of a Curious Phenomenon observed at Carrington Moss. By Chas. O'Neil, F.C.S.

On the rapidity of the Growth of Plants. By Charles Clay, M.D.

OCTOBER 15th, 1889.

On a remarkable pattern of Asbestos Cloth on the surface of an Iron Tube. By W. Thomson, F.R.S.E., F.C.S., &c.

Arenaria gothica (*E. Fries*) as a plant new to Britain. By Charles Bailey, F.L.S.

Selections from the Correspondence of Lieut.-Colonel John Leigh Philips, of Mayfield, Manchester. Part I. By F. J. Faraday, F.L.S.

OCTOBER 29th, 1889.

On the Law of Cooling, and its bearing on the Theory of the Motion of Heat in Bars. By Charles H. Lees, M.Sc., Berkeley Fellow of Owens College. Communicated by Arthur Schuster, Ph.D., F.R.S.

On an apparatus for determining the viscosity of liquids, with a Bibliography of the subject. By W. H. Haldane Gee, B.Sc., F.C.S.

NOVEMBER 12th, 1889.

On a possible Cause of Error in taking the Temperature of Patients. By Alexander Hodgkinson, M.B., B.Sc.

A Criticism of Dr. Croll's Theory of Alternate Glacial and Warm Periods in each Hemisphere, and of Interglacial Climates. By Henry H. Howorth, M.P., F.S.A.

NOVEMBER 26th, 1889.

On specimens of Cuttle-fish from the *Challenger* Collection. By W. E. Hoyle, M.A., M.R.C.S.

Additional Note on the Rate of Dissolution of Solids. By James Bottomley, D.Sc., B.A., F.C.S.

On the Levanter Clouds at Gibraltar. By J. J. Ashworth.

DECEMBER 10th, 1889.

On Joule's Explanation of the varying dips of Magnetic Needles of different lengths. By Arthur Schuster, Ph.D., F.R.S.

On Iridescent Chlorate of Potash. By Alexander Hodgkinson, M.B., B.Sc.

On the latest report of the Solar Physics Committee. By F. J. Faraday, F.L.S.

On the combination of Hydrogen and Chlorine, alone, and in presence of other gases. By Harold B. Dixon, M.A., F.R.S., Professor of Chemistry, and J. A. Harker, Research Student in the Owens College.

JANUARY 7th, 1890.

The Author of the Glacial Theory. By Henry H. Howorth, M.P., F.S.A.

JANUARY 21st, 1890.

On two unpublished letters by James Anderson, LL.D., the Scotch Agriculturist and Economist, dated December 24th, 1794, and July 24th, 1795, respectively. By F. J. Faraday, F.L.S.

Sphenophyllum as a branch of *Asterophyllites*. By A. C. Seward, M.A., F.G.S., St. John's College, Cambridge. Communicated by W. C. Williamson, LL.D., F.R.S.

FEBRUARY 4th, 1890.

On a Spectrum observed in the Blackpool Aquarium. By Alexander Hodgkinson, M.B., B.Sc.

On the recent abundance of Jack-snipes. By Francis Nicholson, F.Z.S.

On M. Gustave-Adolphe Hirn. By R. W. Gwyther, M.A.

FEBRUARY 18th, 1890.

On Dr. H. C. Buys Ballot. By Arthur Schuster, Ph.D., F.R.S.

MARCH 4th, 1890.

On specimens of Triassic Sandstone from the North of Spain. By W. Semmons. Communicated by C. A. Burghardt, Ph.D., F.C.S.

On some applications of Caustic Soda or Potash and Carbon in the qualitative and quantitative analysis of minerals. By Charles A. Burghardt, Ph.D., F.C.S.

MARCH 18th, 1890.

On an Improved Form of Gauge for Measuring the Thickness of Metal Sheets, Rods, and other Substances from three-fourths to one ten-thousandth part of an inch. By W. H. Johnson, B.Sc.

On Absorption Spectra and a method for their more Accurate Determination. By Alexander Hodgkinson, M.B., B.Sc.

APRIL 1st, 1890.

On Diamonds and Double Refraction. By Alexander Hodgkinson, M.B., B.Sc.

On Meteorology at the Sea-side : English Channel. By Dr. W. G. Black, F.R.Met.S. Communicated by R. F. Gwyther, M.A.

APRIL 15th, 1890.

On Thomas Augustine Arne as an inventor of musical form. By Chas. J. Hall, D.Mus. Lond.

APRIL 29th, 1890.

Hymenoptera Orientalis, or contributions to a knowledge of the Hymenoptera of the Indian Zoological Region. Part II. by P. Cameron. Communicated by John Boyd.

The Levenshulme Limestones. By William Brockbank, F.L.S., F.G.S.

Description of a New Reflecting Telescope and Observatory at Bowdon, Cheshire. By Samuel Okell, F.R.A.S.

On the Flexure of a Flat Elastic Spring. By Horace Lamb, M.A., F.R.S.

List of Societies and other Public Bodies and Institutions sending their publications, and of periodicals regularly added to the Library, in exchange or by purchase.

Agen	Société d'Agriculture, Sciences, et Arts.
Amsterdam	Koninklijik Akademie van Wetenschappen.
,,	Koninklijk Zoologisch Genootschap.
,,	Wiskundig Genootschap.
Abbeville	Société d'Emulation.
Aberdeen	Philosophical Society.
Adelaide	Royal Society of S. Australia.
Albany	New York State Agricultural Society.
Amiens	Société Linnéenne du Nord de la France.
Angers	Académie des Sciences et Belles-Lettres.
Arras	Académie des Sciences.
Baltimore	Johns Hopkins University.
Basel	Die Naturforschende Gesellschaft.
Batavia	Natur-Vereeniging in Nederlandisch Indie.
Bath	Bath and West of England Society.
Belfast	*Ulster Agriculturist.*
Berlin	Deutsche Chemische Gesellschaft.
,,	Physikalische Gesellschaft.
,,	Entomologischer Verein.
,,	Gesellschaft für Erdkunde.
,,	*Journal für die reine und angewandte Mathematik.*
,,	Königl. Preussische Akademie der Wissenschaften.
,,	Polytechnische Gesellschaft.
Berne	Bernische Naturforschende Gesellschaft.
,,	Schweizerische naturforschende Gesellschaft.
Berwick	Berwickshire Naturalists' Club.
Besançon	Société d'Emulation du Doubs.
Birkenhead	Literary and Scientific Society.
Birmingham	Institution of Mechanical Engineers.
,,	Midland Institute of Mining, Civil, and Mechanical Engineers.
,,	Philosophical Society.
Bologna	Accademia delle Scienze dell' Istituto.
Bolton	Free Library.
Bombay	Bataviaash Genootschap van Kursten en Wetensch.
,,	Branch of the Royal Asiatic Society.
Bonn	Preussische Naturhistorische Verein.
Bordeaux	Société des Sciences Physiques et Naturelles.

Boston, U. S. A.	American Academy of Arts and Sciences.
,,	Society of Natural History.
Bradford	Free Library.
Bremen	Naturwissenschaftlicher Verein.
Brisbane	Royal Society of Queensland.
Bristol	Naturalists' Society.
Brussels	Académie Royale de Médecine.
,,	Académie Royale de Science.
,,	Observatoire Royale.
Buckhurst Hill	*Essex Naturalist.*
Budapest	Ungarische Akademie der Wissenschaften.
Burnley	Mechanics Institute.
Caen	Académie Nationale des Sciences.
Calcutta	Agricultural and Horticultural Society of India.
,,	Asiatic Society of Bengal.
,,	Geological Survey of India. Geological Museum.
,,	Meteorological Reporter to the Government of India.
Cambridge	Observatory.
,,	Philosophical Society.
,,	University Library.
Cambridge, U.S.A.	Harvard College.
Cape Town	South African Philosophical Society.
Cassel	Verein für Naturkunde.
Catania	Accademia Gioenia di Scienze naturali.
Chambéry	Académie des Sciences.
,,	Institut National Genevois.
Chatham	Royal Engineers' Institute.
Cherbourg	Société Nationale des Sciences Naturelles.
Chicago	Public Library.
Christiania	Kongelige Norske Frederiks Universitet.
,,	Observatory.
,,	Société des Sciences.
Cincinnati	Society of Natural History.
Copenhagen	Kongelige Danske Videnskabenses-Selskab.
,,	Kong. Nordiske Oldskrift-Selskab.
Danzig	Naturforschende Gesellschaft.
Davenport	Academy of Natural Sciences.
Delft	Ecole Polytechnique.
Dijon	Académie des Sciences, Arts, et Belles-Lettres.
Dorpat	Naturforscher Gesellschaft.
Douai	Société Centrale d'Agriculture, Sciences, &c.
Draguignan	Société d'études Scientifiques.
Dublin	Library of Trinity College.
,,	Royal Dublin Society.
,,	Royal Geological Society of Ireland.
,,	Royal Irish Academy.
,,	Statistical and Social Inquiry Society of Ireland.

Dublin	University Biological Association.
Durham	Observatory of the University.
Dunkirk	Société Dunkerguoise pour l'encouragement des Sciences.
Edinburgh	Advocates' Library.
,,	Botanical Society.
,,	Geological Society.
,,	Royal Observatory.
,,	Royal Physical Society.
,,	Royal Scottish Society of Arts.
,,	Royal Society.
,,	Scottish Meteorological Society.
Epinal	Société d'émulation du département des Vosges.
Evreux	Société libre d'Agriculture, Sciences, &c.
Falmouth	Royal Cornwall Polytechnic Society.
Frankfurt-am-Main	Physikalischer Verein.
,,	Senckenbergische Naturforschende Gesellschaft.
Freiburg	Naturforschende Gesellschaft.
Geneva	*Archives des Sciences Physiques.*
,,	Société de Physique et d'Histoire Naturelle.
Giessen	Oberhessiche Gesellschaft für Natur- und Heilkunde.
Glasgow	Geological Society.
,,	Institution of Engineers and Ship-builders.
,,	Natural History Society.
,,	Philosophical Society.
,,	University.
Görlitz	Naturforschende Gesellschaft.
,,	Oberlausitzische Gesellschaft der Wissenschaften.
Gotha	*Petermann's Mittheilungen.*
Göttingen	Königliche Gesellschaft der Wissenschaften.
Granville	Scientific Laboratories of Denison University.
Graz	Verein der Aerzte in Steiermark.
Greenwich	Royal Observatory.
Haarlem	Hollandsche Maatschappij der Wetenschappen.
,,	Nederlandsche Maatschappij.
,,	Teyler's Stiftung.
Hague	Koninklijk Instituut van Ingenieurs.
Halle an der Sale	Naturforschende Gesellschaft.
,,	Kaiserliche Leopold-Carol. Akad. der Naturforscher.
Halifax	Literary and Philosophical Society.
,,	Yorkshire Geological Society and Polytechnic Society.
Hannover	Architecten- und Ingenieur-Verein.
,,	Naturhistorische Gesellschaft.
Heidelberg	Naturhistorisch-Medicinische Verein.
Helsingfors	Finska Vetenskaps Societeten.
Hermannstadt	Siebenbürgischer Verein für Natur.
Hertford	Hertfordshire Natural History Society.
Hobart Town	Royal Society of Tasmania.
Hong-kong	Observatory.

Huddersfield	Yorkshire Naturalists' Union.
Kansas	Academy of Science, Topeka.
Karlsruhe	Grossherzogliche Sternwarte.
Kazan	Imperial University.
Kiel	Naturwissenschaftlicher Verein für Schleswig-Holstein.
,,	Königl. Universitäts-Bibliothek.
,,	Ministerial Kommission zur Untersuchung der deutschen Meere in Kiel.
Kiev	Société des Naturalistes.
Königsberg	Kön. Physik.-Oekonomische Gesellschaft.
,,	Königl. Universitäts-Sternwarte.
Lausanne	Société Vaudoise des Sciences Naturelles.
Leeds	Philosophical and Literary Society.
Leicester	Literary and Philosophical Society.
Leiden	Maatschappij der Nederlande Letterkunde.
Le Mans	Société d'Agriculture, Sciences, &c.
Leipzig	*Annalen der Chemie.*
,,	*Wiedermann's Annalen der Physik und Chemie.*
,,	Astronomische Gesellschaft.
,,	*Botanische Zeitung.*
,,	Fürstlich Jablonowskische Gesellschaft.
,,	*Jahrbücher für Wissenschaftliche Botanik.*
,,	Kön. Sächsische Gesellschaft der Wissenschaften.
,,	Naturforschende Gesellschaft.
,,	*Zeitschrift für Wissenschaftliche Zoologie.*
Leeuwarden	Friesch Genootschap v. geschied oud heid-en Taalkunde.
Lewisham	West Kent Natural History and Microscopical Society.
Liège	Société Royale des Sciences.
,,	Société Géologique de Belgique.
Lisbon	Academia real das. Sciencias de Lisboa.
,,	Observatorio de Infante D. Luiz-em Lisboa.
Liverpool	Geological Society.
,,	Historic Society of Lancashire and Cheshire.
,,	Literary and Philosophical Society.
,,	Mersey Docks and Harbour Board.
,,	Polytechnic Society.
,,	Science Students' Association.
London	*Annals and Magazine of Natural History.*
,,	British Association for the Advancement of Science.
,,	British Museum.
,,	*Chemical News.*
,,	Chemical Society.
,,	East India Association.
,,	*Entomologist.*
,,	*Entomologists' Monthly.*
,,	*Gardeners' Chronicle.*
,,	*Geological Record.*
,,	*Ibis.*

London	Geological Society.
,,	Institute of Actuaries.
,,	Institution of Civil Engineers.
,,	*Iron.*
,,	*Journal of Botany.*
,,	Linnean Society.
,,	*London, Dublin, and Edinburgh Philosophical Magazine.*
,,	Mathematical Society.
,,	*Messenger of Mathematics.*
,,	Meteorological Office of the Board of Trade.
,,	Museum of Practical Geology.
,,	National Association for the Promotion of Social Science.
,,	*Nature.*
,,	Palæontographical Society.
,,	Pali Text Society.
,,	Pharmaceutical Society.
,,	Physical Society.
,,	Quekett Microscopical Club.
,,	*Quarterly Journal of Mathematics.*
,,	,, *Journal of Microscopical Science.*
,,	Ray Society.
,,	Registrar General.
,,	Royal Agricultural Society.
,,	Royal Archæological Institute.
,,	Royal Asiatic Society.
,,	Royal Astronomical Society.
,,	Royal Geographical Society.
,,	Royal Horticultural Society.
,,	Royal Institute of British Architects.
,,	Royal Institution of Great Britain.
,,	Royal Medical and Chirurgical Society.
,,	Royal Meteorological Society.
,,	Royal Microscopical Society.
,,	Royal Society.
,,	Royal Statistical Society.
,,	Royal United Service Institution.
,,	Society of Antiquaries.
,,	Society of Arts.
,,	*Zoologist.*
,,	*Zoological Record.*
,,	Zoological Society.
Lucca	Reale Accademia Lucchese di Scienze, Lettere, ed Arti.
Lund	Königliche Carolinische Universität.
Luxembourg	Société des Sciences naturelles du Grand-Duché.
Lyons	Académie des Sciences, Belles-Lettres et des Arts.
Madison	State Historical Society of Wisconsin.
,,	Academy of Sciences, Arts, &c.

Madison	Wisconsin State Agricultural Society.
Madras	Meteorological Department.
Madrid	Real Academia de Ciencias.
Malvern	Naturalists' Field Club.
Manchester	Association of Employers, Foremen, and Draughtsmen.
,,	Chamber of Commerce.
,,	Free Library.
,,	Field Naturalists' Society.
,,	Geological Society.
,,	Microscopical Society.
,,	Statistical Society.
,,	Scientific Students' Association.
,,	Technical School.
,,	Athenæum.
,,	Chetham Library.
,,	Literary Club.
,,	Mayor and Corporation.
,,	Victoria University.
Manchester and Salford Sanitary Association.	
Manitoba	Historical and Scientific Society.
Marburg	Gesellschaft zur Beförderung der gesammten Naturwissenschaften.
Melbourne	Royal Society of Victoria.
,,	Registrar General's Office.
Meriden	Scientific Association.
Metz	Académie.
Mexico	Ministerio di Fomento.
,,	Central Meteorological Observatory.
Middleburg	Zeeuwsch Genootschap der Wetenschappen.
Middlesbrough	Iron and Steel Institute.
Milan	Reale Istituto Lombardo di Scienze, &c.
,,	Società Italiana di Scienze Naturali.
,,	Reale Osservatorio di Brera.
Minneapolis	Minnesota Academy of Natural Sciences.
Modena	R. Accademia di Scienze, Lettere, et Arti.
,,	R. Osservatorio.
Montpellier	Académie des Sciences, Lettres, &c.
Montreal	McGill University.
,,	Natural History Society.
,,	Royal Society of Canada.
Moscow	Société Impériale des Naturalistes.
Mount Hamilton	Lick Observatory.
Mulhouse	Société Industrielle.
Munich	Kön. Akademie der Wissenschaften.
,,	Polytechnischer Verein für das Königreich.
,,	Königliche Sternwarte Bogenhausen bei München.
Nancy	Société des Sciences.
,,	Société des Sciences Naturelles.

Naples	Accademia della Soc. Reale di Scienze.
Neu-Brandenburg	Verein der Freunde der Naturgeschichte.
Neuchatel	Société des Sciences Naturelles.
Newcastle-on-Tyne	Literary and Philosophical Society.
,,	Natural History Society.
,,	North of England Institute of Mining and Mechanical Engineers.
,,	Society of Chemical Industry.
Newhaven	Connecticut Academy of Arts & Sciences.
New York	Academy of Sciences.
,,	American Geographical and Statistical Society.
,,	American Museum of Natural History.
,,	Astor Library.
,,	Meteorological Observatory.
	Plymouth Institution and Devon and Cornwall Natural History Society.
,,	Trustees of the Cooper Union for the Advancement of Science.
Nîmes	Académie.
Offenbach-am-Main	Offenbacher Verein für Naturkunde.
Oldham	Lyceum.
Ottowa	Geological and Natural History Survey of Canada.
Oxford	Radcliffe Observatory.
,,	Bodleian Library.
Palermo	Reale Accademia di Scienze, &c.
Paris	*Annales des Mines.*
,,	*Annales des Sciences Naturelles.*
,,	*Astronomie.*
,,	Académie des Sciences de l'Institut de France.
,,	Ecole Polytechnique.
,,	Société Nationale d'Agriculture.
,,	Musée d'Histoire Naturelle.
,,	Société Botanique de France.
Philadelphia	Academy of Natural Sciences.
,,	*American Naturalist.*
,,	American Philosophical Society.
,,	Franklin Institute.
Prague	K. K. Sternwarte.
,,	Kön. Böhmische Gesellschaft der Wissenschaften.
Raleigh	Elisha Mitchell Scientific Society.
Regensburg	Zoologisch-Mineralogischer Verein.
Reims	Académie.
Riga	Naturforscher-Verein.
Rio de Janeiro	Instituto Historico.
Rochdale	Literary and Scientific Society.
Rochelle	Société des Sciences naturelles de la Charente.
Rome	Accademia dei Lincei.
,,	Accademia Pontifica di Nuovi Lincei.

Rouen	Académie.
Salem	American Association for the Advancement of Science.
,,	Essex Institute.
Salford	Royal Museum and Library.
,,	Mayor and Corporation.
San Francisco	California Academy of Sciences.
Santiago	Deutsche Wissenschaftliche Verein.
Sheffield	Literary and Philosophical Society.
Southampton	Ordnance Survey Office.
St.-Etienne	Société de l'Industrie minérale.
St. Louis	Academy of Sciences.
Stockholm	Konglija Vetenskaps Akademien.
,,	Sveriges Geologiska Undersökning.
Stockport	Public Free Library.
St.-Petersbourg	Académie Impériale des Sciences.
,,	Observatoire Physique Central.
Strasburg	Universitäts- und Landes-Bibliothek.
Stuttgart	*Neues Jahrbuch für Mineralogie, Geologie, und Paleontologie.*
Sydney	Royal Society of New South Wales.
Tasmania	Royal Society.
Taunton	Somersetshire Archæological and Natural History Society.
Throndhjem	Kon. Norske Videnskabers Selskabs.
Tokio, Japan	University.
Toronto	Canadian Institute.
Toulouse	Académie des Sciences.
Troyes	Société d'Agriculture, Sciences, Arts, &c.
Turin	Association Météorologique Italienne.
Upsala	Kongl. Universitet.
,,	Kongl. Vetenskaps Societeten.
Utrecht	Kongl. Nederlandsch Meteorologische Institut.
,,	Provinciaal Utrechtsch Genootschap.
Valenciennes	Société d'Agriculture, Sciences, et Arts.
Venice	Regio Instituto Venetio di Scienze, Lettere, ed Arti.
Vienna	Kaiserl. Akademie der Wissenschaften.
,,	Kaiserl. Königl. Geographische Gesellschaft.
,,	,, ,, Geologische Reichsanstalt.
,,	,, ,, Sternwarte.
,,	,, ,, Zoologisch-Botanische Gesellschaft.
,,	Oesterreichische Gesellschaft für Meteorologie.
,,	Oesterreichischer Ingenieur-Verein.
Warrington	Museum and Library.
Washington	Bureau of Statistics. Treasury Department.
,,	Department of Agriculture.
,,	Department of the Interior. Geological Survey.
,,	Library of the War Department.
,,	National Academy of Sciences.

Washington	Naval Observatory.
,,	Philosophical Society.
,,	Surgeon General's Office.
,,	Smithsonian Institution.
,,	United States Patent Office.
,,	,, ,, Coast Survey.
Watford	Natural History Society, Herts.
Wiesbaden	Nassauische Verein für Naturkunde.
Wisconsin	Naturhistorischer Verein.
,,	State Historical Society.
Würzburg	Physikalisch-Medicinische Gesellschaft.
Yale	University Observatory.
York	Yorkshire Philosophical Society.
Zurich	Naturforschende Gesellschaft.
,,	Meteorologische Centralanstalt der Schweizer Naturf. Gesellschaft.

MANCHESTER LITERARY AND

Charles Bailey, Treasurer, in Account with the Society,
Statement of the Accounts

Dr.

	1889-90.		1888-9.	
1890—March 31st:—	£ s. d.	£ s. d.	£ s. d.	£ s. d.
To Cash in hand, 1st April, 1889		335 8 2		218 5 7
To Members' Contributions:—				
Old Members, 1887-8, 1 Subscription at 42s.	2 2 0			
,, 1888-9 11 Subscriptions ,, ...	23 2 0			
,, 1889-90, 95 ,, ,, ...	199 10 0			
,, 1890-1, 1 ,, ,, ...	2 2 0			
New Members, 1889-90, 5 ,, ,, ...	10 10 0			
,, ,, 7 Half ,, 21s.	7 7 0			
,, ,, 17 Admission Fees at 42s.	35 14 0			
Compounder's Fee (Mr. N. Bradley, F.C.S.)	26 5 0			
		306 12 0		287 14 0
To Library Subscriptions:—				
One Natural History Associate at 10s.		0 10 0		0 10 0
To Contributions from Sections:—				
Microscopical and Natural History Section, 1889-90 ..	5 5 0		7 7 0	
Physical and Mathematical Section .. 1889-90 ..	2 2 0		2 2 0	
		7 7 0		9 9 0
To Use of the Society's Rooms:—				
Manchester Geological Society to 31st March, 1890 ..	30 0 0		60 0 0	
Manchester Medical Society to 30th September, 1889 ..	25 0 0		25 0 0	
Manchester Photographical Society to 30th Sept., 1889 ..	25 0 0		25 0 0	
Manchester Scientific Students' Asso. to 30th Sept., 1889 ..	9 0 0		9 0 0	
		89 0 0		119 0 0
To Sales of the Society's Publications, 1889-90		5 1 11		4 13 3
To Natural History Fund, 1889-90:—				
Dividends on £1225, Great Western Railway Co. Stock ..		59 14 4		59 13 1
To Bank Interest, less Bank Postages, 1889-90		4 8 1		2 15 6
To Donation from Local Committee, British Association ..		.. .. ..		51 0 7
		£808 1 6		£753 1 0
1890.—April 1. To Cash in Manchester and Salford Bank, Limited				£277 5 10

PHILOSOPHICAL SOCIETY.

from 1st April, 1889, to 31st March, 1890, with a Comparative for the Session 1888-1889.

Cr.

	1889-90.		1888-9.	
1890—March 31st:—	£ s. d.	£ s. d.	£ s. d.	£ s. d.
By Charges on Property:—				
Chief Rent (Income Tax deducted)	12 12 0		12 11 5	
Income Tax on Chief Rent	0 6 3		0 6 3	
Insurance against Fire	13 17 6		13 17 6	
Repairs, &c.	8 10 3		5 3 6	
Cases for Dalton Apparatus	24 14 0		.. .. ..	
		60 0 0		31 18 8
By House Expenditure:—				
Coal, Gas, Candles, Water, &c.	33 6 9		31 9 9	
Tea, Coffee, &c., at Meetings	13 16 7		10 14 3	
Cleaning, Brushes, &c.	6 12 2		5 13 10	
		53 15 6		47 17 10
By Administrative Charges:—				
Clerk and Housekeeper	62 8 0		62 8 0	
Postages and Carriage of Parcels	27 1 11		21 16 10	
Stationery, Printing Circulars, Receipts, and Engrossing	11 15 11		15 0 4	
Distributing 'Memoirs'	6 7 9		5 19 9	
		107 13 7		105 4 11
By Publishing:—				
Honorarium for editing the Society's publications	50 0 0		.. .. ..	
Printing and Binding 'Memoirs,' old series	.. .. ..		31 10 0	
Printing and Binding 'Memoirs and Proceedings,' new series	80 3 0		97 18 0	
Wood Engraving and Lithography	31 19 8		.. .. ..	
Preparing Index to 'Memoirs and Proceedings,' all the series	.. .. ..		5 0 0	
		162 2 8		134 8 0
By Library:—				
Binding Books in Library	52 2 8		.. .. ..	
Books and Periodicals	14 18 1		14 18 3	
Assistant in Library	8 10 0		9 10 0	
Palæontographical Society for the year 1890	1 1 0		1 1 0	
Ray Society for the year 1890	1 1 0		1 1 0	
Zoological Record, Vol. 25	1 0 0		1 0 0	
		78 12 9		27 10 3
By Natural History Fund:—				
Works on Natural History	18 11 2		16 13 2	
Grant to Microscopical and Natural History Section	50 0 0		40 0 0	
Plates for Natural History Papers in 'Memoirs'	.. .. ..		14 0 0	
		68 11 2		70 13 2
By Balance 31st March, 1890		277 5 10		335 8 2
		£808 1 6		£753 1 0

Audited and Found Correct, April 29th, 1890,

R. HOLMES,
FRANCIS JONES.

Summary Balance Sheet, Session 1889-90.

		£ s. d.	£ s. d.
General Account :—			
Balance in favour of this Account, 1st April, 1889		106 17 4	
Receipts during the Session 1889-90		386 14 0	
		493 11 4	
Expenditure for binding Books during the Session 1889-90	£17 4 6		
Other Expenditure ,, ,,	410 1 10		
		427 6 4	
Balance in favour of this Account, 31st March, 1890			66 5 0
Compounders' Fund :—			
Balance in favour of this Account, 1st April, 1889		151 5 0	
Mr. N. Bradley's compounding fee, received 29th October, 1889		26 5 0	
Balance in favour of this Account, 31st March, 1890			177 10 0
Natural History Fund :—			
Balance in favour of this Account 1st April, 1889		42 7 8	
Dividends on Great Western Railway Co.'s Stock, 1889-90		59 14 4	
		102 2 0	
Expenditure during the Session 1889-90		68 11 2	
Balance in favour of this Account 31st March, 1890			33 10 10
Binding Fund :—			
Expenditure during the Session 1889-90		52 2 8	
Balance in favour of this Account 1st April, 1889		34 18 2	
Transferred to General Account to close this fund 31st March, 1890		17 4 6	.. .. ..
Cash in Manchester and Salford Bank Limited, 31st March, 1890			£277 5 10

Annual Report of the Council of the Microscopical and Natural History Section.

The Section has held the usual number of monthly meetings during the session, but lately the attendance has somewhat fallen off. With so small a number of members and associates on the roll, it is hardly to be expected that there should be a large average attendance, and it seems as though the only remedy for this state of affairs would be that a special effort should be made to induce a greater number of the microscopists, naturalists, botanists, etc., of this district to join the Section. The inducements the Society offers to such students are very great. It has a first-rate set of microscopes and accessories, a large collection of microscopical specimens, and a library containing sets of the memoirs and transactions of most of the learned societies of Europe and America; besides many valuable books on natural history, botany, etc. It is a pity that these should not be made more use of. It may be that these advantages are not sufficiently known, and it is probably needful for the members and associates of the Section to bestir themselves and do a bit of recruiting. The Society prints in its *Memoirs* any original papers of merit that may be submitted, and owing to its exchanges with all the principal scientific societies, this gives a wide publicity.

The following is a list of members and associates of the Section :—

Members :—Thos. Alcock, M.D., J. J. Ashworth, Chas. Bailey, F.L.S., Walter Edward Barratt, John Barrow, John Boyd, Henry Brogden, F.G.S., Alfred Brown, M.D., Samuel Cottam, F.R.A.S., Edward Coward, Robert Ellis Cunliffe, R. D. Darbishire, B.A., F.G.S., Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S., Hastings C. Dent, F.L.S.,

W. K. DEANE, FREDERICK JAS. FARADAY, F.L.S., CHAS. JAMES HEYWOOD, ALEX. HODGKINSON, B.SC., M.B., CHARLES HERBERT HURST, J. ARTHUR HUTTON, HENRY HOYLE HOWORTH, F.S.A., M.P., Prof. A. MILNES MARSHALL, M.A., M.D., D.SC., F.R.S., J. COSMO MELVILL, M.A., F.L.S., J. E. MORGAN, M.D., M.A., FRANCIS NICHOLSON, F.Z.S., EDMUND SALIS SCHWABE, B.A., Prof. W. C. WILLIAMSON, LL.D., F.R.S.

Associates :—WILLIAM BLACKBURN, F.R.M.S., E. S. BLES, M.B., PETER CAMERON, HERBERT C. CHADWICK, E. PYEMONT COLLETT, PETER CUNLIFFE, F. R. CURTIS, G. J. CROSBIE DAWSON, H. L. EARL, B.A., JAMES FLEMING, F.R.M.S., JOHN RAY HARDY, FRANK HUET, L.D.S., R.C.S., HENRY HYDE, LESLIE JONES, M.D., H. L. KNOOP, W. LEACH, A. A. MUMFORD, M.B., M.R.C.S., L.R.C.P., J. B. PETTIGREW, THOMAS ROGERS, GEORGE NASH SKIPP, MARK STIRRUP, F.G.S., THEODORE SINGTON, J. TATHAM, B.A., M.D., W. LADD TORRANCE, EDWARD WARD, F.R.M.S., SIDNEY YOUNG, D.SC., W. R. SCOWCROFT.

Total 27 members and 27 associates, against 29 members and 30 associates at the corresponding period of last year.

The Microscopical and Natural History Section of the Manchester Literary and Philosophical Society in account with the Parent Society for Grant for Books from the Natural History Fund.

Dr. *From 2nd April, 1889, to 31st March, 1890.* **Cr.**

Date		£	s.	d.
1890.				
Mar. 10.	To Grant by Parent Society per Treasurer	50	0	0
		£50	0	0

To Balance of Grant unexpended £38 9 11

Date		£	s.	d.
1889.				
April	By Balance owing to the Section	3	2	4
,,	,, Fowler's Coleoptera 11 Parts. Nos. 28-38	2	5	10
June 20.	,, Challenger Publications, Zoology, Vol. 31	1	13	4
Nov. 6.	,, Do. 32	1	0	10
,,	,, Brit. Hieracia, Parts 1-4	1	4	0
1890.				
Feb. 10.	,, Challenger Publications, Physics and Chemistry, Vol. 2	2	3	9
	,, Balance	38	9	11
		£50	0	0

Mark Stirrup, Treasurer, in account with the Microscopical and Natural History Section of the Manchester Literary and Philosophical Society.

Dr. **Cr.**

Date		£	s.	d.
1889.				
Apl.	To Balance in Manchester and Salford Bank (St. Ann's Street)	42	14	7
Dec. 20.	,, Bank Interest	0	12	3
1890.				
Mar. 10.	,, Grant by Parent Society from Natural History Fund	50	0	0
	,, Subscriptions and Arrears, Session 1889-90 (from 1st April, 1889, to 31st March, 1890)	26	10	0
		£119	16	10

Examined April 18th, 1890, and found correct,
(Signed) HENRY HYDE,
EDWD. P. COLLETT.

To Balance to Credit of Section £95 7 2

Date		£	s.	d.
1889.				
May 14.	By West Newman and Co., Journal of Botany, 1889	0	12	0
June 20.	,, Jas. E. Cornish, Fowler's Coleoptera, Parts 28-30	0	12	6
,,	,, Do. "Challenger," Zool., Vol. 31	1	13	4
Aug. 15.	,, Do. Fowler's Coleoptera, Part 31	0	4	2
,,	,, Do. Microscopical Journal and Naturalist	1	8	6
Nov. 6.	,, Do. "Challenger," Zool., Vol. 32	1	0	10
,,	,, Do. Fowler's Coleoptera, 32-34, Microscopical Journal, &c.	1	2	4
,,	,, Fred. J. Hanbury, British Hieracia, Parts 1-4	1	4	0
11.	,, C. Simms and Co., Circulars and Cards	0	13	0
,,	,, Jas. Collins and Co., Envelopes	0	4	6
1890.				
Feb. 10.	,, J. E. Cornish. Fowler's Coleoptera, Parts 35-36	0	8	4
,,	,, Do. "Challenger," Physics and Chemistry, Vol. 2	2	3	9
11.	,, Gurney and Jackson, Ibis, 1890	1	1	0
21.	,, Chas. Simms and Co., Circulars and Cards	0	19	0
Mar. 28.	,, J. E. Cornish, Fowler's Coleoptera, Part 37 and Naturalist	0	5	5
,,	,, Do. do. Part 38	0	4	2
,,	,, Parent Society, Sectional Contribution	5	5	0
,,	,, Chas. Hargreaves, Teas, £2. 13s. 4d.; Postage, &c. £1. 7s. 2d.	4	0	6
31.	,, J. E. Cornish, Microscopical Journal, Dec., 1889	0	8	4
,,	,, C. Simms & Co., Circulars, January to March	0	16	6
,,	,, John Boyd, Oil & Postage	0	2	6
,,	,, Balance in Manchester and Salford Bank, St. Ann's-st.	95	7	2
		£119	16	10

THE COUNCIL AND MEMBERS.

APRIL 29, 1890.

President.

EDWARD SCHUNCK, PH.D., F.R.S., F.C.S.

Vice-Presidents.

WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S.,
FOREIGN MEMBER OF THE ROYAL SWEDISH ACAD. SC., AND OF THE ROYAL SOCIETY OF GÖTTINGEN.

OSBORNE REYNOLDS, M.A., LL.D., F.R.S.

ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S.

JAMES BOTTOMLEY, B.A., D.SC., F.C.S.

Secretaries.

FREDERICK JAMES FARADAY, F.L.S., F.S.S.

REGINALD F. GWYTHER, M.A.

Treasurer.

CHARLES BAILEY, F.L.S.

Librarian.

FRANCIS NICHOLSON, F.Z.S.

Other Members of the Council.

WILLIAM HENRY JOHNSON, B.Sc.

JAMES COSMO MELVILL, M.A., F.L.S.

JOHN BOYD.

HAROLD B. DIXON, M.A., F.R.S.

ALEXANDER HODGKINSON, M.B., B.Sc.

JOHN F. W. TATHAM, B.A., M.D.

Honorary Members.

Date of Election.	
1847, April 20.	Adams, John Couch, LL.D., F.R.S., V.P.R.A.S., F.C.P.S., Director of the Observatory, and Lowndsean Prof. of Astron. and Geom. in the Univ. of Cambridge. Cor. Mem. Inst. Fr. (Acad. Sci.). &c. *The Observatory, Cambridge.*
1843, April 18.	Airy, Sir George Biddell, K.C.B., M.A., D.C.L., LL.D., Hon. Mem. R.S.E., R.I.A., F.C.P.S., For. Mem. Inst. Fr. (Acad. Sci.), &c. *The White House, Croom's Hill, Greenwich Park, S.E.*
1887, April 19.	Armstrong, Lord, C.B., D.C.L., LL.D. *Newcastle-on-Tyne.*
1886, Feb. 9.	Baker, Sir Benjamin, LL.D., M. Inst. C.E. 2, *Queen's Square Place, Westminster, S.W.*
1886, Feb. 9.	Baker, John Gilbert, F.R.S. *Kew.*
1886, Feb. 9.	Berthelot, Prof. Marcellin, For. Mem. R.S., Membre de l'Institut. *Paris.*
1886, Feb. 9.	Buchan, Alexander, F.R.S.E. 72, *Northumberland Street, Edinburgh.*
1860, April 17.	Bunsen, Robert Wilhelm, Ph.D., For. Mem. R.S., late Prof. of Chemistry at the Univ. of Heidelberg. *Heidelberg.*
1888, April 17.	Cannizzaro, S., Prof. of Chemistry. *University of Rome.*
1889, April 30.	Carruthers, William, Pres. L.S., F.R.S. Keeper of Botanical Dept., British Museum.
1859. Jan. 25.	Cayley, Arthur, M.A., LL.D., D.C.L., V.P.R.A.S., F.C.P.S., Sadlerian Prof. of Pure Maths. in the Univ. of Cambridge, Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *Garden House, Cambridge.*
1886, Oct. 30.	Clifton, Robert Bellamy, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy, Oxford. *New Museum, Oxford.*
1889, April 30.	Cohn, Ferdinand, Professor of Botany. 26, *Schweidnitze Stadtgraben, Breslau.*
1887, April 19.	Cornu, Professor Alfred, For. Mem. R.S., Membre de l'Institut. *Ecole Polytechnique, Paris.*
1886, Feb. 9.	Dawson, Sir John William, C.M.G., M.A., F.R.S., LL.D., F.G.S. *McGill College, Montreal.*
1888, April 17.	Dewalque, Gustave, Professor of Geology. *University of Liège.*
1889, April 30.	Farlow, W. G., Professor of Botany. *Harvard College, Cambridge, Mass., U.S.A.*

Date of Election.	
1889, April 30.	Flower, William Henry, C.B., LL.D., F.R.S. Director of Nat. Hist. Dept., British Museum.
1889, April 30.	Foster, Michael, M.A., M.D., LL.D., Sec. R.S., Professor of Physiology. *Trinity College, Cambridge.*
1860, Mar. 9.	Frankland, Edward, Ph.D., M.D., LL.D., D.C.L., V.P.C.S., F.R.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *The Yews, Reigate Hill, Reigate.*
1843, Feb. 7.	Frisiani, nobile Paola, Pros., late Astron. at the Observ. of Brera. Milan, Mem. Imper. Roy. Instit. of Lombardy, Milan, and Ital. Soc. Sc. *Milan.*
1889, April 30.	Hertz, H., Professor of Physics. *Bonn.*
1848, Jan. 25.	Hind, John Russell, LL.D., F.R.S., F.R.A.S., Superintendent of the Nautical Almanac. Cor. Mem. Inst. Fr. (Acad. Sci.) 3, *Cambridge Park Gardens, Twickenham.*
1881, April 17.	Hittorf, Johann Wilhelm, Professor of Physics. *Polytechnicum, Münster.*
1886, Feb. 9.	Helmholtz, Geheimrath Herman von, LL.D., For. Mem. R.S. Präsident der Physikalisch-technischen Reichsanstalt *Berlin.*
1866, Jan. 23.	Hofman, A. W., Ph.D., M.D., LL.D., F.R.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. 10, *Dorotheenstrasse, Berlin.*
1869, Jan. 12.	Huggins, William, LL.D., D.C.L., F.R.S., F.R.A.S., Cor. Mem. Inst. Fr. (Acad. Sci.). 90, *Upper Tulse Hill, Brixton, London, S.W.*
1872, April 30.	Huxley, Thomas Henry, M.D., Ph.D., LL.D., D.C.L., P.P.R.S., Hon. Prof. of Biology in Royal School of Mines. Cor. Mem. Inst. Fr. (Acad. Sci.), &c. 4, *Marlborough Place, Abbey Road, N.W.*
1852, Oct. 16.	Kirkman, Rev. Thomas Penyngton, M.A., F.R.S., *Croft Rectory, near Warrington.*
1886, Feb. 9.	Kopp, Prof. Hermann. *Heidelberg.*
1887, April 19.	Langley, Prof. S. P., *Alleghany Observatory, Pittsburg, U.S.*
1887, April 19.	Laveleye, Emile de, *Liège University.*
1887, April 19.	Lockyer, Norman, F.R.S., Cor. Mem. Inst. Fr., (Acad. Sci.). *Science School, Kensington.*
1889, April 30.	Lubbock, Sir John, Bart., M.P., D.C.L., LL.D., F.R.S. 15, *Lombard Street, E.C.*
1889, April 30.	Mendeléeff, D., Professor of Chemistry. *St. Petersburg.*
1889, April 30.	Meyer, Lothar, Professor of Chemistry. *Tübingen.*
1887, April 19.	Newcomb, Prof. Simon, For. Mem. R.S. *Johns Hopkins University, Baltimore, U.S.*

Date of Election.	
1844, April 30.	Owen, Sir Richard, K.C.B., M.D., LL.D., F.R.S., F.L.S., F.G.S., V.P.Z.S., F.R.C.S. Ireland, Hon. M.R.S.E., For. Assoc. Inst. Fr. (Acad. Sci.), &c. *Sheen Lodge, Richmond.*
1886, Feb. 9.	Pasteur, Louis, For. Mem. R.S., Membre de l'Institut. *Paris.*
1851, April 29.	Playfair, Rt. Hon. Sir Lyon, K.C.B., LL.D., Ph.D., F.R.S., F.G.S., M.P., V.P.C.S, &c. 68, *Onslow Gardens, London, S. W.*
1866, Jan. 23.	Prestwich, Joseph, F.R.S., F.G.S., Cor. Mem. Inst. Fr. (Acad. Sci.) *Shoreham, near Sevenoaks.*
1866, Jan. 23.	Ramsay, Sir Andrew Crombie, LLD., F.R.S., F.G.S., 15, *Cromwell Crescent, South Kensington, London.*
1849, Jan. 23.	Rawson, Robert, F.R.A.S. *Havant, Hants.*
1886, Feb. 9.	Rayleigh, John William Strutt, Lord, M.A., D.C.L., (Oxon.), LL.D. (Univ. McGill), Sec.R.S., F.R.A.S., *Terling Place, Witham, Essex.*
1887, April 19.	Römer, Dr. Fred. *Breslau.*
1889, April 30.	Résal, Professor Henri, Membre de l'Institut. *Ecole Polytechnique, Paris.*
1889, April 30.	Roscher, Dr. Wilhelm, K. Geheimer Rath, and Professor of Political Economy. *Leipsic.*
1889, April 30.	Routh, Edward John, Sc.D., F.R.S. *Newnham Cottage, Cambridge.*
1872, April 30.	Sachs, Julius von, Ph.D. *Würzburg.*
1889, April 30.	Salmon, Revd. George, D.D., D.C.L., LL.D,, F.R.S., Regius Professor of Divinity. *Provost's House, Trinity College, Dublin.*
1889, April 30.	Siemens, Dr. Ernst Werner von, Geheimer Rath. 94, *Markgrafenstrasse, Berlin.*
1869, Dec. 14.	Sorby, Henry Clifton, LL.D., F.R.S., F.G.S., &c. *Broomfield, Sheffield.*
1851, April 29.	Stokes, Sir George Gabriel, Bart., M.A., M.P., LL.D., D.C.L., Pres. R.S., Lucasian Professor of Mathem. Univ. Cambridge, F.C.P.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *Lensfield Cottage, Cambridge.*
1886, Feb. 9.	Strasburger, Professor. *Bonn.*
1861, Jan. 22.	Sylvester, James Joseph, M.A., D.C.L., LL.D., F.R.S. Savilian Prof. of Geom. in the Univ. of Oxford, Cor. Mem. Inst. Fr. (Acad. Sci.) &c. *New College, Oxford.*
1868, April 28.	Tait, Peter Guthrie, M.A., F.R.S.E., &c., Professor of Natural Philosophy, Edinburgh. 38, *George Square, Edinburgh.*

Date of Election.	
1851, April 22.	Thomson, Sir William, M.A., D.C.L., LL.D., F.R.S.S. L. and E. Prof. of Nat. Phil. in Univ. of Glasgow. For. Assoc. Inst. Fr. (Acad. Sci.), 2, *College, Glasgow.*
1872, April 30.	Trécul, A., Member of the Institute of France. *Paris.*
1886, Feb. 9.	Tylor, Edward Burnett, F.R.S., D.C.L. (Oxon), LL.D. (St. And. and McGill Colls.), Keeper of University Museum. *Oxford.*
1868, April 28.	Tyndall, John, LL.D., M.D., D.C.L., Ph.D., F.R.S., F.C.S. *Haslemere.*
1889, April 30.	Williamson, Alexander William, Ph.D., LL.D., Corr. Mem. Inst. Fr. (Acad. Sci.). *High Pitfold, Shottermill, Haslemere.*
1886, Feb. 9.	Young, Prof. C. A. *Princeton College, N.J., U.S.*
1888, April 17.	Zirkel, Ferdinand, Professor of Mineralogy. *University of Leipsic.*

Corresponding Members.

1860, April 17.	Ainsworth, Thomas. *Cleator Mills, near Egremont, Whitehaven.*
1861, Jan. 22.	Buckland, George, Professor, University College, Toronto. *Toronto.*
1870, March 8.	Cockle, The Hon. Sir James, M.A., F.R.S., F.R.A.S., F.C.P.S. 12, *St. Stephen's Road, Bayswater, London.*
1866, Jan. 23.	De Caligny, Anatole, Marquis, Corresp. Mem. Acadd. Sc. Turin and Caen, Socc. Agr. Lyons, Sci. Cherbourg, Liège, &c.
1861, April 2.	Durand-Fardel, Max, M.D., Chev. of the Legion of Honour, &c. 36, *Rue de Lille, Paris.*
1849, April 17.	Girardin, J., Off. Legion of Honour, Corr. Mem. Instit. France, &c. *Lille.*
1850, April 30.	Harley, Rev. Robert, F.R.S., F.R.A.S. 17, *Wellington Square, Oxford.*
1882, Nov. 14.	Herford, Rev. Brooke. *Arlington Street, Boston, U.S.*

Date of Election.	
1862, Jan. 7.	Lancia di Brolo, Frederico, Duc, Inspector of Studies, &c. *Palermo.*
1859, Jan. 25.	Le Jolis, Auguste-François, Ph.D. Archiviste perpétuel and late President of the Soc. Nat. Sc. Cherbourg, &c. *Cherbourg.*
1857, Jan. 27.	Lowe. Edward Joseph, F.R.S., F.R.A.S., F.G.S., Mem. Brit. Met. Soc., &c. *Shirenewton Hall, near Chepstow.*
1862, Jan. 7.	Nasmyth, James, C.E., F.R.A.S., &c. *Penshurst, Tunbridge.*
1867, Feb. 5.	Schönfeld, Edward, Ph.D., Director of the Mannheim Observatory.

Ordinary Members.

1888, Nov. 13.	Adams, C. N., B.A., *The Hulme Grammar School, Alexandra Road.*
1861, Jan. 22.	Alcock, Thomas, M.D., Extr. L.R.C.P. Lond., M.R.C.S., Engl., L.S.A. *Oakfield, Ahton-on-Mersey.*
1873, Jan. 7.	Allmann, Julius. 70, *Deansgate.*
1870, Dec. 13.	Angell, John, F.C.S., F.I.C. 81, *Ducie Grove; Oxfora Road.*
1861, Jan. 22.	Anson, Ven. Archd. George Henry Greville, M.A., *Birch Rectory, Rusholme.*
1885, Nov. 17.	Armstrong, Thomas, F.R.M.S. *Brookfield, Urmston ; Deansgate.*
1837, Aug. 11.	Ashton, Thomas, 36, *Charlotte Street.*
1881, Nov. 1.	Ashton, Thomas Gair, M.A., M.P. 36, *Charlotte Street.*
1887, Nov. 16.	Ashworth, J. Jackson. 39, *Spring Gardens, City.*
1865, Nov. 15.	Bailey, Charles, F.L.S. *Ashfield, College Road, Whalley Range, Manchester.*
1888, Nov. 13.	Bailey, G. H., D.Sc., Ph.D. *The Owens College.*
1888, Feb. 7.	Bailey, Alderman W. H. *Summerfield, Eccles New Road.*
1876, Nov. 28.	Barratt, Walter Edward. *Kersal, Higher Broughton.*
1867. Nov. 12.	Barrow, John. *Beechfield, Folly Lane, Swinton.*
1889, Jan. 8.	Beard, J. R. *Richmond Grove, Longsight.*
1868, Dec. 15.	Bickham, Spencer H. *Oakwood, Alderley Edge.*
1861, Jan. 22.	Bottomley, James, D.Sc., B.A., F.C.S. 220, *Lower Broughton Road.*

Date of Election.	
1889, Jan. 22.	Bowman, George, M.D. *Monifieth, Stretford Road, Old Trafford.*
1875, Nov. 16.	Boyd John. *Barton House, No.* 11, *Didsbury Park, Didsbury.*
1889, Oct. 15.	Bradley, Nathaniel, F.C.S. 51, *Chapman Street, Hulme.*
1855, April 17.	Brockbank, William, F.G.S., F.L.S. *Chapel Walks, City.*
1861, April 2.	Brogden, Henry, F.G.S. *Hale Lodge, Altrincham.*
1844, Jan. 22.	Brooks, Sir William Cunliffe, Bart., M.A., M.P. *Bank,* 92, *King Street.*
1889, April 16.	Brooks, Herbert S. *Slade House, Levenshulme.*
1860, Jan. 23.	Brothers, Alfred, F.R.A.S. 12, *Swinton Avenue, Manchester.*
1886, April 6.	Brown, Alfred, M.A., M.B. *Claremont, Higher Broughton.*
1846, Jan. 27.	Browne, Henry, M.A. (Glas.), M.R.C.S. (Lond.), M.D. (Lond.). *Heaton Mersey.*
1889, Jan. 8.	Brownell, T. M. *School Board Offices, Deansgate, Manchester.*
1889, Oct. 15.	Budenberg, C. F., M.Sc. 25, *Demesne Road, Alexandra Road.*
1872, Nov. 12.	Burghardt, Charles Anthony, Ph.D. 35, *Fountain Street.*
1854, April 18.	Christie, Richard Copley, M.A., Chancellor of the Diocese, *The Elms, Roehampton, S. W.*
1841, April 30.	Clay, Charles, M.D., Extr. L.R.C.P. (Lond)., M.R.C.S. (Edin.). *Tower Lodge, Poulton-le-Fylde, Lanc.*
1886, Dec. 14.	Cohen, J. B., Ph.D. *The Owens College.*
1884, Nov. 4.	Corbett, Joseph. 9, *Albert Square.*
1853, Jan. 25.	Cottam, Samuel, F.R.A.S., F.R. Hist. S., F.C.A. 49, *Spring Gardens.*
1859, Jan. 25.	Coward, Edward. *Heaton Mersey, near Manchester.*
1861, Nov. 12.	Coward, Thomas. *Higher Downs, Altrincham.*
1849, Jan. 25.	Crowther, Joseph Stretch. *Endsleigh, Alderley Edge.*
1876, April 18.	Cunliffe, Robert Ellis. *The Poplars, Eccles Old Road, Eccles.*
1871, Nov. 8.	Dale, Richard Samuel, B.A., 1, *Chester Terrace, Chester Road.*
1853, April 19.	Darbishire, Robert Dukinfield, B.A., F.S.A., F.G.S., 26, *George Street.*
1878, Nov. 26.	Davis, Joseph. *Engineer's Offices, Lancashire and Yorkshire Railway, Hunt's Bank.*
1869, Nov. 2.	Dawkins, William Boyd, M.A., F.R.S., F.G.S., Assoc. Inst. C.E., Hon. Fellow Jesus College, Oxford; Professor of Geology in Owens College. *The Owens College.*
1861, Dec. 10.	Deane, William King. *Almondbury Place, Chester Road.*
1879, Mar. 18.	Dent, Hastings Charles, F.L.S., F.R.G.S. 20, *Thurloe Square, London, S. W.*

Date of Election.	
1878, Feb. 8.	Dixon, Harold B., M.A., F.R.S., Professor of Chemistry. *The Owens College.*
1886, Mar. 9.	Dodgshon, John. *Moorside, Davenport, Stockport.*
1883, Oct. 2.	Faraday, Frederick James, F.L.S., F.S.S. *Ramsay Lodge, Slade Lane, Levenshulme.*
1886, Feb. 9.	Gee, W. W. Haldane, B.Sc. *The Owens College.*
1890, Jan. 7.	Glazebrook, Michael George, M.A., High Master of the Grammar School. *Halton Bank, Pendleton.*
1881, Nov. 1.	Greg, Arthur. *Eagley, near Bolton.*
1874, Nov. 3.	Grimshaw, Harry, F.C.S. *Thornton View, Clayton.*
1888, Feb. 7.	Grimshaw, William. *Stoneleigh, Sale.*
1875, Feb. 9.	Gwyther, R. F., M.A., Fielden Lecturer in Mathematics, Owens College. *The Owens College, and* 33, *Heaton Road, Withington.*
1889, Nov. 12.	Hadley, H. E. *The Owens College.*
1889, Nov. 12.	Hall, Charles John, Mus. Doc. *Hawkesmoor, Southport.*
1890, Feb. 18.	Harker, Thomas. *Brook House, Fallowfield.*
1890, Jan. 7.	Harrison, Fred., B.A. *The Grammar School.*
1862, Nov. 4.	Hart, Peter. *Messrs. Tennants & Co., Mill Street, Clayton, N., Manchester.*
1873, Dec. 16.	Heelis, James. 71, *Princess Street.*
1890, Mar. 4.	Henderson, H. A. 20, *York Chambers, Brazennose Street.*
1828, Oct. 31.	Henry, William Charles, M.D., F.R.S. *Haffield, near Ledbury, Herefordshire.*
1889, Jan. 8.	Heywood, Chas. J. *Chaseley, Pendleton.*
1833, April 26.	Heywood, James, F.R.S., F.G.S., F.S.A. 26, *Kensington Palace Gardens, London, W.*
1864, Mar. 22.	Heywood, Oliver. *Bank, St. Ann's Street.*
1884, Jan. 8.	Hodgkinson, Alexander, M.B., B.Sc. 18, *St. John Street, Manchester.*
1846, Jan. 27.	Holden, James Platt. 3, *Temple Bank, Smedley Lane, Cheetham.*
1887, April 19.	Holmes, Ralph, B.A. *Hulme Grammar School, Alexandra Park.*
1882, Oct. 17.	Holt, Henry. *The Cedars, Didsbury.*
1873, Dec. 2.	Howorth, Henry H., F.S.A., M.P. *Bentcliffe House, Eccles.*
1889, Oct. 15.	Hoyle, W. E., M.A., Keeper of the Manchester Museum. 25, *Brunswick Road, Withington.*
1884, Jan. 8.	Hurst, Charles Herbert. *The Owens College.*
1888, April 17.	Hutton, James Arthur. 29, *Dale Street.*
1870, Nov. 1.	Johnson, William H., B.Sc. 26, *Lever Street.*
1878, Nov. 26.	Jones, Francis, F.R.S.E., F.C.S. *Grammar School.*

Date of Election.	
1885, Dec. 1.	Jones, Henry, B.A. *Norman Road, Rusholme.*
1890, Jan. 7.	Joseland, H. L., B.A. *The Grammar School.*
1886, Jan. 12.	Kay, Thomas, J.P. *Moorfield, Stockport.*
1852, Jan. 27.	Kennedy, John Lawson. 47, *Mosley Street.*
1886, Mar. 9.	Lamb, Horace, M.A., F.R.S., Professor of Mathematics at the Owens College. *Burton Road, Didsbury.*
1863, Dec. 15.	Leake, Robert, M.P. *The Dales, Whitefield.*
1884, April 15.	Leech, Daniel John, Professor, M.D. *The Owens College.*
1850, April 30.	Leese, Joseph. *Messrs. S. & E. Leese, Fylde Road Mill, Preston.*
1884, Jan. 22.	London, Rev. Herbert, M.A. 7, *Berkeley Terrace, Wimbledon.*
1857, Jan. 27.	Longridge, Robert Bewick. *Yew Tree House, Tabley, Knutsford.*
1870, April 19.	Lowe, Charles, F.C.S. *Summerfield House, Reddish, Stockport.*
1866, Nov. 13.	McDougall, Arthur B.Sc. *Clifton Lodge, Gore Street, Greenheys.*
1859, Jan. 25.	Maclure, John William, M.P., F.R.G.S., *Whalley Range.*
1875, Jan. 26.	Mann, John Dixon, M.D., M.R.C.P., Lond. 16, *St. John Street.*
1879, Dec. 2.	Marshall, Arthur Milnes, M.A., M.D., D.Sc., F.R.S., Professor of Zoology, Owens College. *The Owens College.*
1864, Nov. 1.	Mather, William. *Iron Works, Salford.*
1873, Mar. 18.	Melvill, James Cosmo, M.A., F.L.S. *Kersal Cottage, Prestwich.*
1879, Dec. 30.	Millar, John Bell, M.E., Assistant Lecturer in Engineering, Owens College. *The Owens College.*
1881, Oct. 18.	Mond, Ludwig, F.C.S. *Winnington Hall, Northwich.*
1861, Oct. 29.	Morgan, John Edward, M.D., M.A., F.R.C.P. Lond., F.R. Med. and Chir. S., Professor of Medicine in the Owens College. 1, *St. Peter's Square.*
1889, April 16.	Moultrie, George W. *Bank of England, King Street, Manchester.*
1873, Mar. 4.	Nicholson, Francis, F.Z.S. 62, *Fountain Street.*
1889, April 16.	Norbury, George. *Hillside, Prestwich Park, Prestwich.*
1862, Dec. 30.	Ogden, Samuel. 10, *Mosley Street, West.*
1884, April 15.	Okell, Samuel, F.R.A.S. *Overley, Langham Road, Bowdon.*
1861, Jan. 22.	O'Neill, Charles, F.C.S., Corr. Mem. Ind. Soc. Mulhouse. *Glen Allan, Manley Road, Whalley Range.*
1844, April 30.	Ormerod, Henry Mere, F.G.S. 5, *Clarence Street.*

Date of Election.	
1861, April 30.	Parlane, James. *Rusholme.*
1876, Nov. 28.	Parry, Thomas, F.S.S. *Grafton House, Ashton-under-Lyne.*
1885, Nov. 17.	Phillips, Henry Harcourt, F.C.S. 183, *Moss Lane East, Manchester.*
1854, Jan. 24.	Pochin, Henry Davis, F.C.S. *Bodnant Hall, Conway.*
1854, Feb. 7.	Ramsbottom, John, M. Inst. C.E. *Fernhill, Alderley Edge.*
1859, April 19.	Ransome, Arthur, M.A., M.D., Cantab., F.R.S., M.R.C.S. 1, *St. Peter's Square.*
1888, Feb. 21.	Rée, Alfred, Ph D., F.C.S. 121, *Manchester Road, Middleton.*
1869, Nov. 16.	Reynolds, Osborne, LL.D., M.A., F.R.S., M. Inst. C.E., Professor of Engineering, the Owens College. *Ladybarn Road, Fallowfield.*
1884, April 3.	Rhodes, James, M.R.C.S. *Glossop.*
1880, Mar. 23.	Roberts, D. Lloyd, M.D., F.R.S. Ed., F.R.C.P. (London). *Ravenswood, Broughton Park.*
1889, April 6.	Robertson, W. J., *Hollins Mount, Heaton Moor, Stockport.*
1864, Dec. 27.	Robinson, John, M. Inst. C.E. *Westwood Hall, Leek.*
1858, Jan. 26.	Roscoe, Sir Henry Enfield, B.A., LL.D., D.C.L., F.R.S., F.C.S., M.P. 10, *Bramham Gardens, Wetherby Road, London, S. W.*
1890, Jan. 21.	Sacré, Howard C., *Breeze House, Higher Broughton.*
1851, April 29.	Sandeman, Archibald, M.A. *Garry Cottage, near Perth.*
1870, Dec. 13.	Schorlemmer, Carl, LL.D., F.R.S., F.C.S. *The Owens College.*
1842, Jan. 25.	Schunck, Edward, Ph.D., F.R.S., F.C.S. *Kersal, Manchester.*
1873, Nov. 18.	Schuster, Arthur, Ph.D., F.R.S., F.R.A.S. *The Owens College.*
1881, Nov. 29.	Schwabe, Edmund Salis, B.A. 41, *George Street.*
1890, Jan. 21.	Sidebotham, James Nasmyth. *Parkfield, Groby Place, Altrincham.*
1886, April 6.	Simon, Henry, C.E. *Darwin House, Didsbury.*
1859, Jan. 26.	Sowler, Sir Thomas. 24, *Cannon Street.*
1889, Oct. 15.	Tatham, John F. W., B.A., M.D., Medical Officer of Health. 247, *Bury New Road, Higher Broughton.*
1884, Mar. 18.	Thompson, Alderman Joseph. *Riversdale, Wilmslow.*
1873, April 15.	Thomson, William, F.R.S.E., F.C.S., F.I.C. *Royal Institution.*
1889, April 30.	Thornber, Harry. *Rookfield Avenue, Sale.*
1860, April 17.	Trapp, Samuel Clement. 88, *Mosley Street.*
1879, Dec. 30.	Ward, Thomas. *Brookfield House, Northwich.*

Date of Election.	
1873, Nov. 18.	Waters, Arthur William, F.G.S. *Villa Vecchia, Davos Dörfli, Switzerland.*
1859, Jan. 25.	Wilde, Henry, F.R.S. *The Hurst, Alderley Edge.*
1859, April 19.	Wilkinson, Thomas Read. *Manchester and Salford Bank, Mosley Street.*
1889, Nov. 12.	Willans, J. W. 28, *Deansgate.*
1874, Nov. 3.	Williams, William Carleton, B.Sc., Professor of Chemistry. *Firth College, Sheffield.*
1888, April 17.	Williams, E. Leader, M.Inst.C.E. *Bowdon, Cheshire.*
1851, April 29.	Williamson, William Crawford, LL.D., F.R.S., Professor of Botany, the Owens College, M.R.C.S. Engl., L.A., For. Mem. Swed. Acad., and Royal Society, Göttingen. *Egerton Road, Fallowfield.*
1889, April 16.	Wilson, Thomas B. 37, *Arcade Chambers, St. Mary's Gate, Manchester.*
1860, April 17.	Woolley, George Stephen. 69, *Market Street.*
1863, Nov. 17.	Worthington, Samuel Barton, M. Inst. C.E. *Mill Bank, Vicarage Lane, Bowdon.*
1865, Feb. 21.	Worthington, Thomas, F.R.I.B.A. 40, *Brown Street.*

N.B.—Of the above list the following have compounded for their subscriptions, and are therefore Life Members:

Bradley, Nathaniel, F.C.S.
Brogden, Henry, F.G.S.
Johnson, William H., B.Sc.
Lowe, Charles, F.C.S.
Sandeman, Archibald, M.A.

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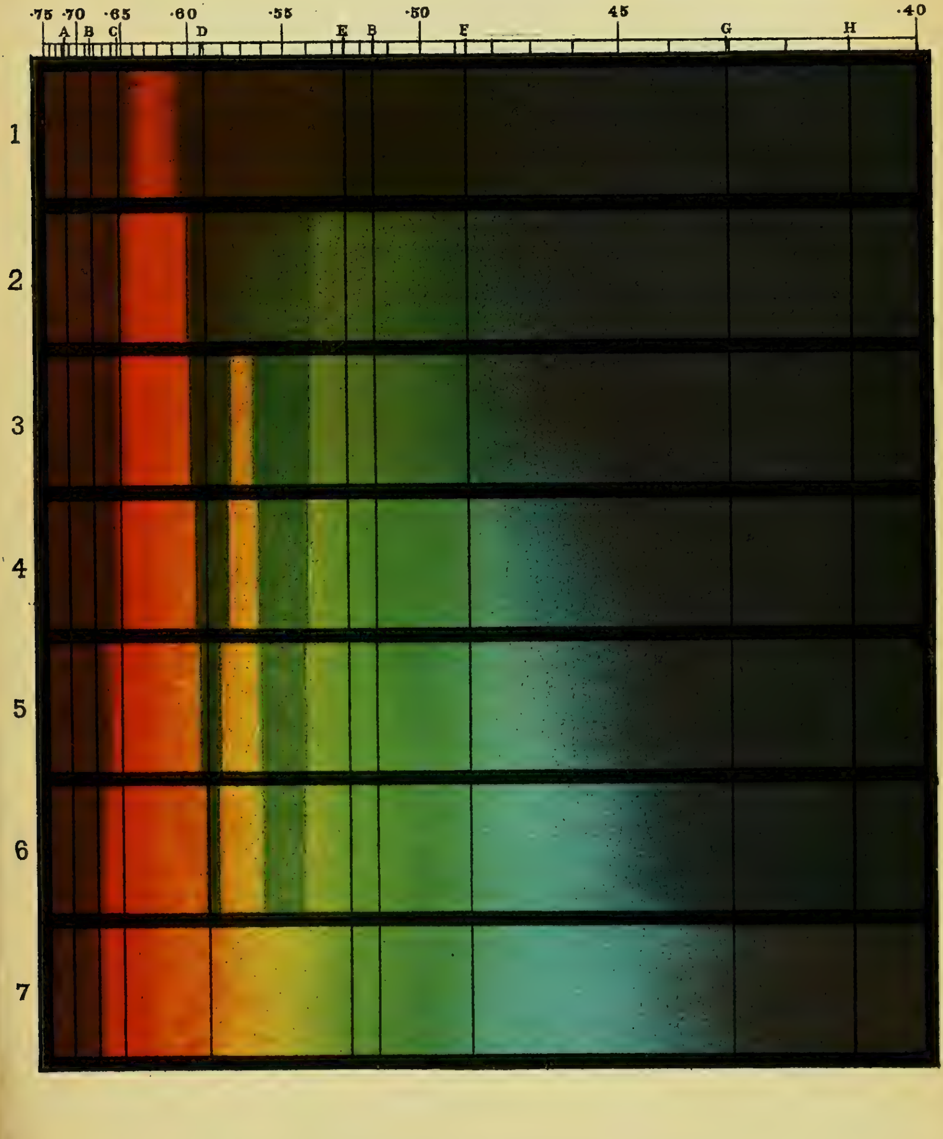
ABSORPTION SPECTRA of BLOOD (Oxyhæmoglobin),

showing Variation in Spectra with different thicknesses of Absorbing Medium.



Spectrum of Wedge-Shaped film of Blood (Oxyhæmoglobin) showing edges of Absorption bands converging to and beyond Apex of Wedge to form line and band respectively of Primitive Spectrum.

FIG 1

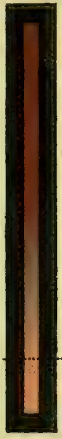


FIG 2

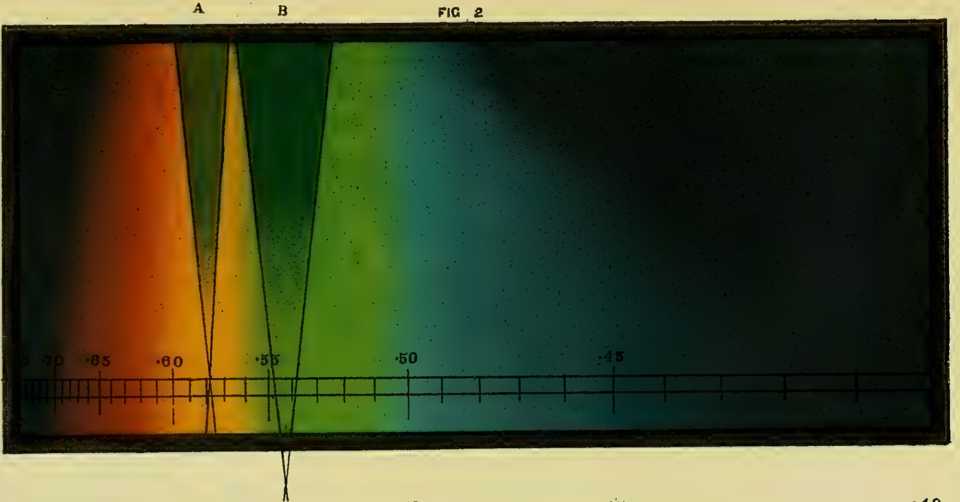
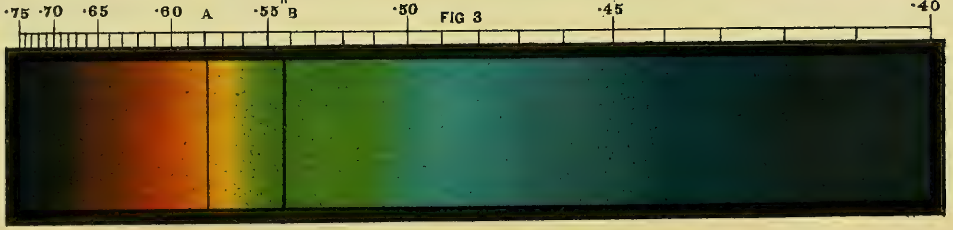
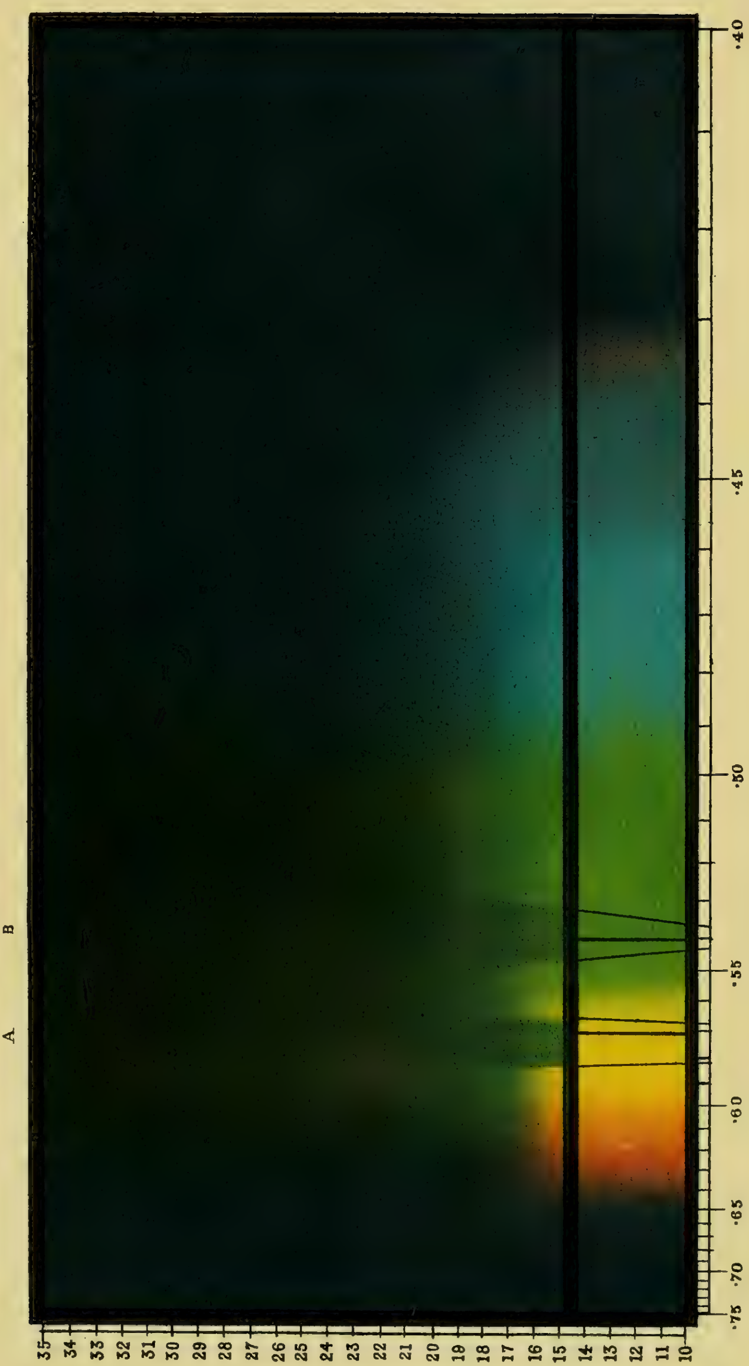


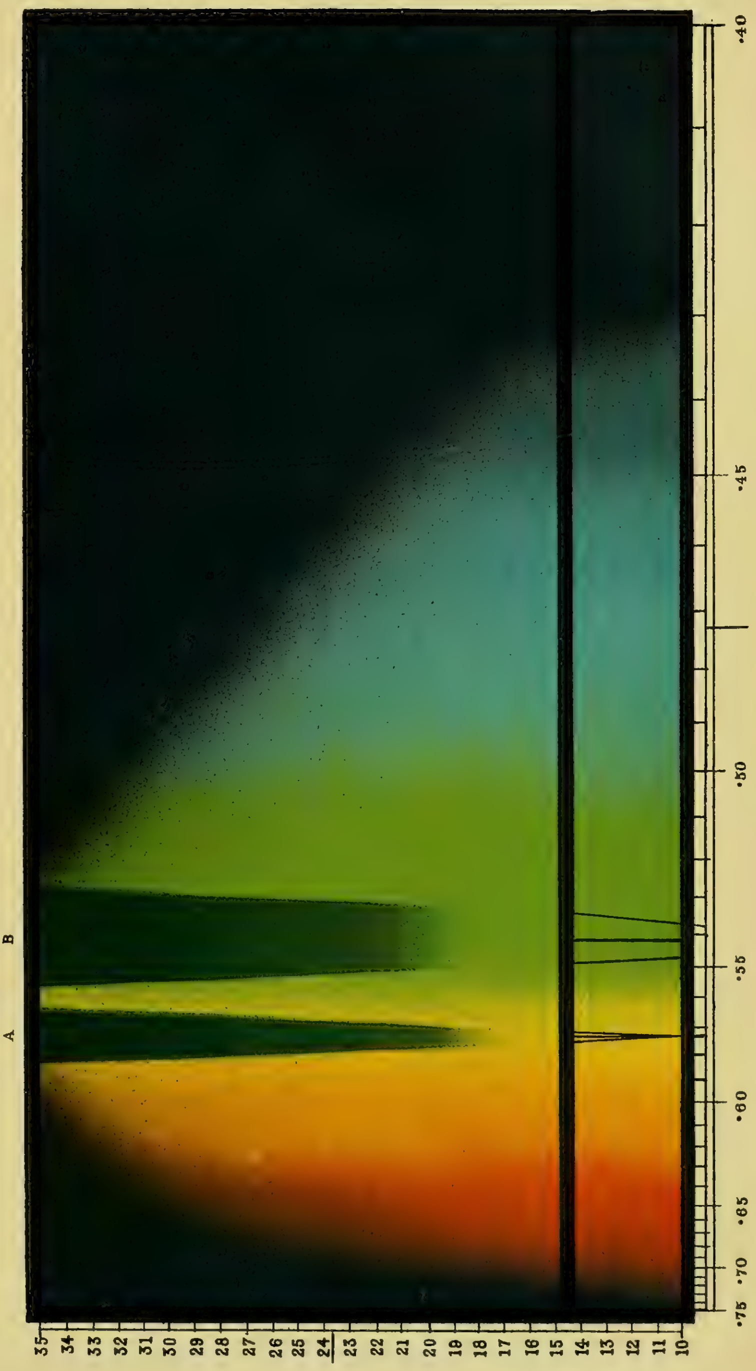
FIG 3



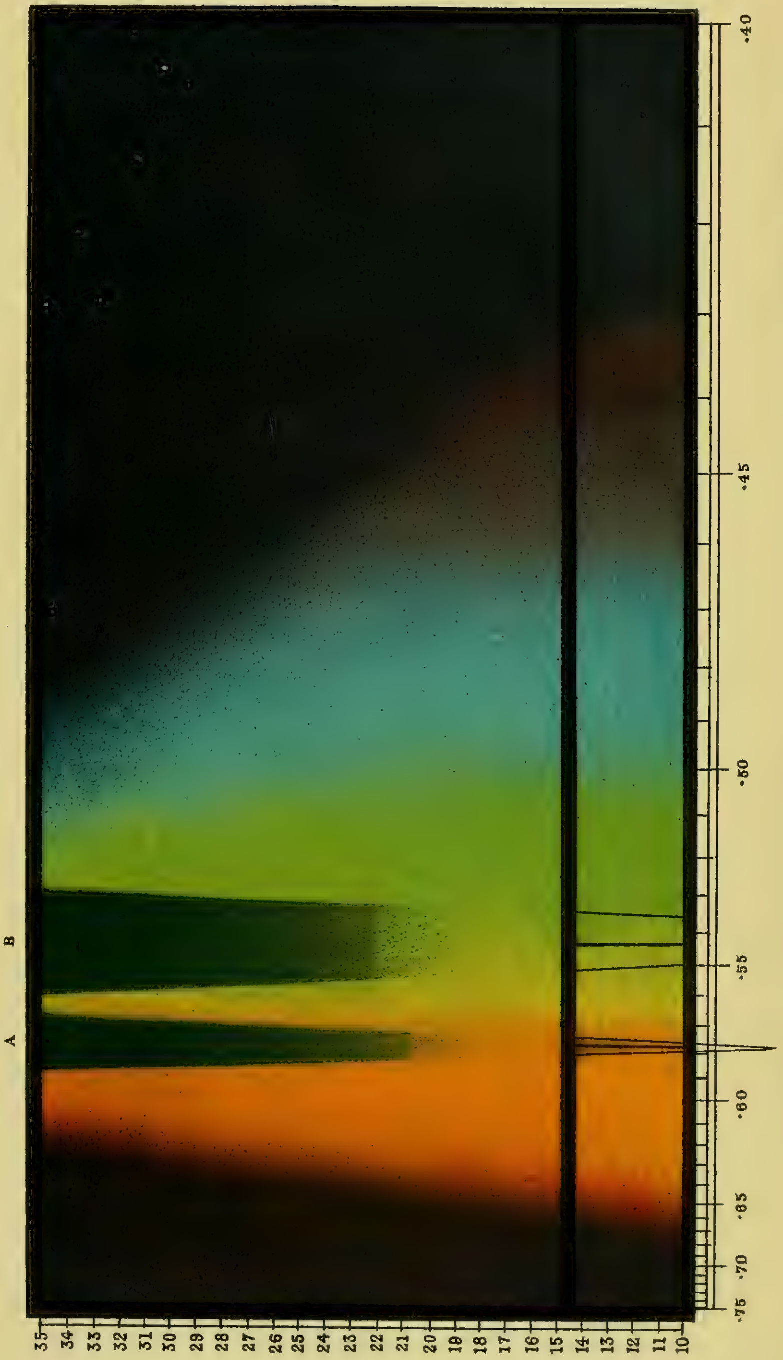
Primitive Spectrum of Human Blood—Oxyhæmoglobin.

SPECTRA of STRONG SOLUTION of Blood to show the effect of Variation in the strength of the Absorbing Medium on the ordinary and primitive Spectra.





SPECTRA *of* WEAK SOLUTION *of Blood to show the effect of Variation in the strength of the Absorbing Medium on the ordinary and primitive Spectra.*



Spectrum of Weak Solution of Blood in Small-angled Wedge-shaped Cell to show the influence of Variation in Angle of Wedge-shaped Cell on Primitive Spectrum.

Primitive Spectra of Blood showing Uniformity with varying conditions of Quantity and Strength of Absorbing Medium, and Angle of Hollow Prism.

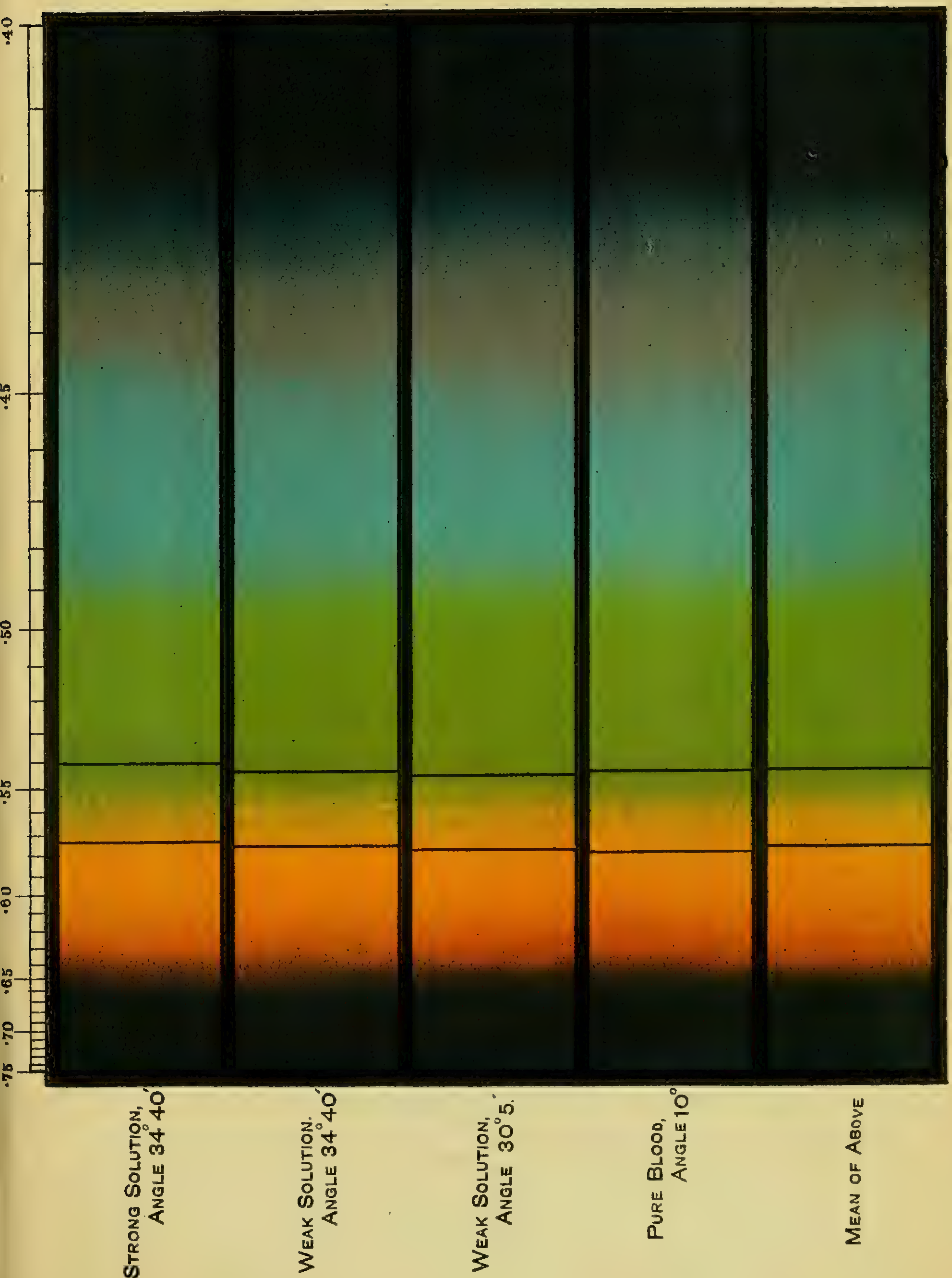
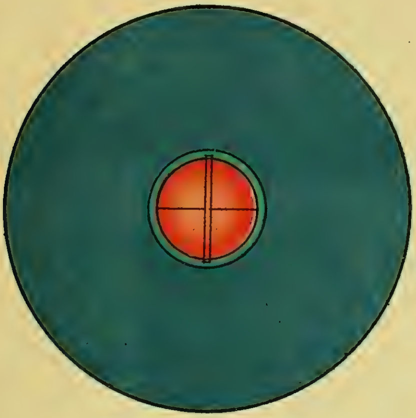


Plate VII.

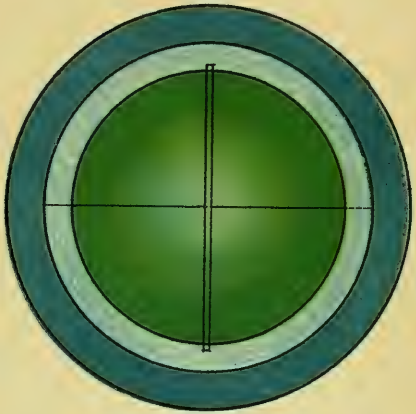
Axial view of Lenticular Cell containing Blood, showing position of Central Line and Spectroscopic Slit.

FIG 2



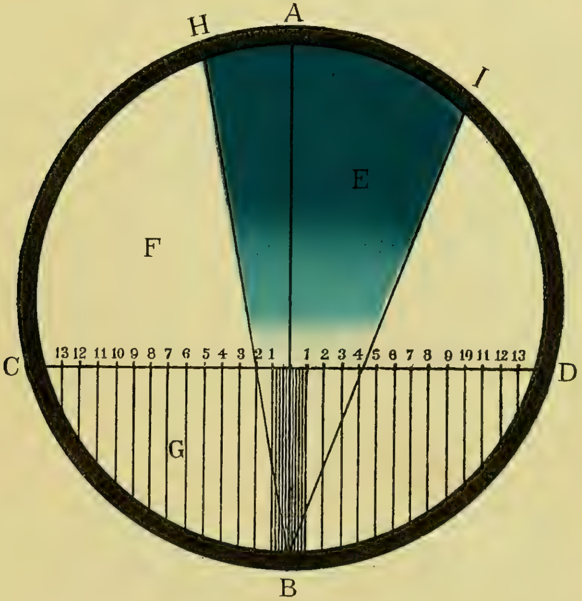
Axial view of Conical Cell containg Chlorophyll, showing position of Central Line and Spectroscopic Slit.

FIG 3



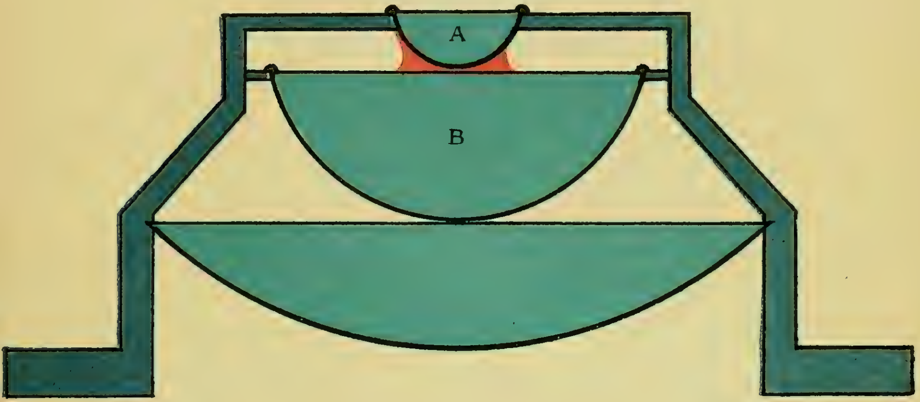
Absorption band with Scale and Moveable Wires in situ to illustrate Method of Centering a Primitive Absorption Line.

FIG 1



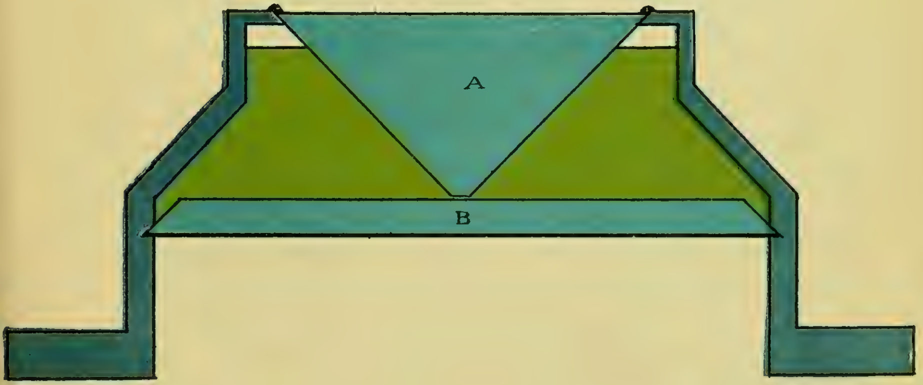
LENTICULAR ABSORPTION CELL (X 10),
for small quantities of Opaque Fluids (Blood, &c.).

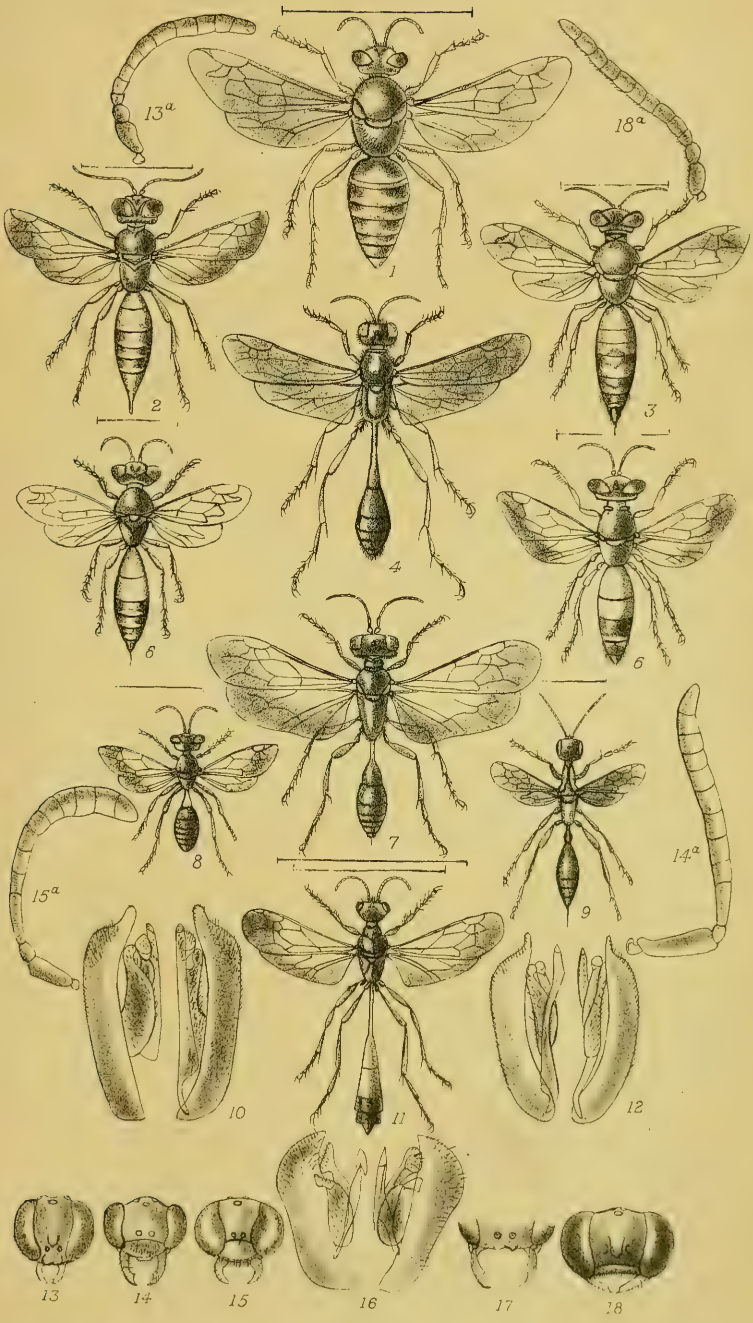
FIG 1



CONICAL ABSORPTION CELL (X 10),
for large quantities of Transparent Fluids (Chlorophyll, &c.)

FIG 2





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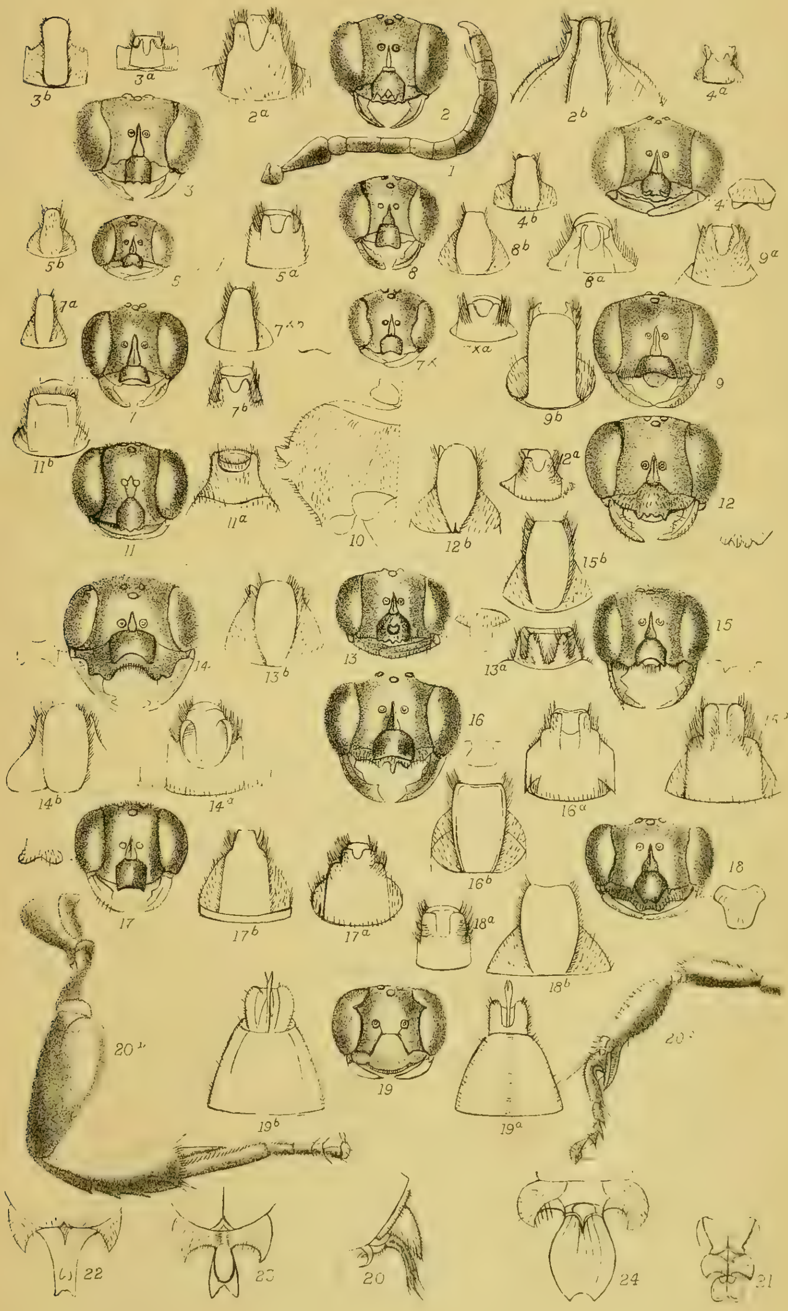

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